EXTREME DEVELOPMENT OF SUCCESSFUL STANDARD COMPOUND FREIGHT LOCOMOTIVE ON SINGLE RIGID WHEEL BASE.

Betterment Briefs

A Collection of
Published Papers on Organized
Industrial Efficiency

BY
H. W. JACOBS

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TO

John William Kendrick

A LEADER OF MEN AND A LEADER IN METHODS WHO HAS THE
RARE QUALITY OF INFUSING INTO HIS SUBORDINATES
AN ENTHUSIASTIC CO-OPERATION UNEQUALED
IN THE INAUGURATION OF A NEW
ORDER OF THINGS

This Book is Dedicated

BY ITS AUTHOR

IN RECOGNITION OF PECULIAR INDEBTEDNESS FOR THE
SUPPORT AND ENCOURAGEMENT GIVEN HIM IN
THE PROSECUTION OF SUCH A WORK
ON A LARGE RAILWAY SYSTEM

PREFACE TO SECOND EDITION.

THE nucleus of the present volume is a series of four articles published by Mr. Jacobs in *The Engineering Magazine* from September, 1906, to January, 1907, under the title "Organization and Economy in the Railway Machine Shop." This was followed in June by a paper on "The Square Deal to the Railway Employee," and concluded a year later, in June, 1908, by a discussion entitled "Personalism in Railroading; a Study of Changing Conditions."

These all appeared in pamphlet reprint editions, quickly exhausted. Later in 1908, the greater part of the work was reissued, somewhat altered in form, and combined with other papers by the same author which had been published from time to time in *The Railroad Gazette* and *The American Engineer and Railroad Journal,* or had been presented before various professional bodies. The entire issue of this enlarged volume, entitled "Betterment Briefs," in turn, was soon absorbed in private and general circulation.

Meanwhile the work on the Santa Fé was proceeding to the development of a new order—new, not only to the road, but to the ideals of railroad operation generally. In the mechanical and stores' departments, in the apprenticeship system, and in all the relation with employees, both financial and friendly, standards were being attained which made the Santa Fé a center of observation and study for railway officials throughout the country. Both inside and outside the organization in which Mr. Jacobs was directing so strong a

motive force, there was need for a logical presentation of the various aspects and activities of the Betterment work—a presentation which should properly correlate the several influences and agencies and show them in their proper proportion and connection with one another.

This book appears as the fulfilment of the need. While it is recrystallized from a portion of the original material, it is a segregation of the best elements contained therein, strengthened and amplified by a great store of new matter amply sufficient to display the present status of Betterment work and to advance its fuller development. It has been prepared at the very focus of the energies with which it deals, and it reflects the actualities as they appear in the daily prosecution of the movement for higher efficiency and better economy in the conduct of a great railway. Above all, it expresses the strong vitality, the watchful intensity, the wide activity, and the energizing personal enthusiasm of its author.

CHARLES BUXTON GOING.

EDITORIAL ROOMS, THE ENGINEERING MAGAZINE, N. Y.
January 8. 1909.

PREFACE TO FIRST EDITION.

THIS volume, which the author presents in the form of matter "printed, not published," is a rather miscellaneous collection in chronological sequence, of such of my papers and others on the new movement for the scientific betterment of American railroading as have appeared in the press from time to time, dealing with those features of the movement with which the writer has had to do.

The book, as an exposition of what has been done, is offered: To those friends and associates who have been in sympathy with the ideals therein portrayed, and whose interest has ofttimes encouraged the work of one who feels more confidence in the handling of tools than in writing about them; to those others who may desire a further acquaintance with the methods and results obtained from the use of these ideals in practice; and to those who may be somewhat conservatively skeptical, but who will perhaps be encouraged in the application of these principles by their demonstrated practical soundness.

It is fitting that I should make due acknowledgment to Mr. A. W. Whiteford (present superintendent of the Sayre shops of the Lehigh Valley Railroad) and to the following members of my staff: Mr. Raffe Emerson, Mr. C. J. Morrison, Mr. Harry Muchnic, Mr. H. H. Lanning, and Mr. B. W. Benedict, who have assisted me in this work, and who have given their interest and spare time in furthering its various features. Other acknowledgments are due to Mr. Harrington Emerson and Mr. Clive Hastings, for constructive criticism.

H. W. JACOBS.

TOPEKA, KAS., February 1, 1908

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COMMERCIAL TOOL METHODS IN RAILROAD SHOPS.

THE success of the modern manufacturing industries depends greatly on their ability to perfect labor-saving devices to cheapen the output of each of their different departments. Up-to-date managers and superintendents of manufacturing concerns are alive to this vital point, and see to it that they have at the heads of their various departments, and particularly in the case of their tool department, the very best man that it is possible for them to secure for the work.

Tool Conditions in Railroad Shops.

As a general thing, railroad shops do not devote much attention to the tool-making question, as private concerns of similar character do. This is due in a great measure to the fact that, in the words of a well-known superintendent of motive power, the railroads "are in the transportation business and not in the manufacturing business." While this may be to a certain extent true, it does not justify the utter disregard of the tool department that some railroads seem to have. It is not the intention to cast any reflection on any member of the great family of railroad officials, but it is nevertheless a lamentable fact that in the majority of cases the tool-room is given but scant attention. In fact, there are cases, known to the writer, of good-sized railroad shops, employing as high as fifty full-pay machinists, which have absolutely no tool-room whatever; the only approach to a tool-room is possibly a wrench rack in some out-of-the-way corner, and what few special tools each individual machinist can keep in his own locker,—although the more he can steal from another man the more he will have for his own. There can be no denying the fact that work done in shops of this sort must of necessity be done in the crudest manner possible, with accompanying disadvantages to the motive-power equipment and output.

It is not to be insinuated that the machine shops of our railroads of today are not in charge of capable men; the fact is, some of as good shop managers as can be found anywhere in the country are in charge of our railroad shops, but a great number of them have been brought up along railroad lines exclusively, and they unconsciously see things from the older railroad point of view only. The effect of this condition of affairs may be seen by considering a few specific cases in the machine shop:

Superiority of Modern Tools and Methods.

For instance, it would never take a lathe man three hours to bolt a crosshead to a face-plate on a lathe and rebore it for a pin fit if the shop had a full equipment of standard piston fit and crosshead reamers.[1]

It would not take one hour to tap out eccentrics by hand if the shop had an automatic tapping device to tap them in the drill press, by which the work could be done in five minutes.

It would not take four hours to bend the arm of a tumbling-shaft and then swing it in the lathe to be able to turn the bearings if they had a tumbling-shaft turning device to do the work.

In place of taking eighteen hours to plane ten eccentric halves by bolting on the planer bed, thirty of them ought to be done in ten hours with a special eccentric-planing jig.

It would not take two hours with a bar and cutters on a drill press to true out knuckle-pin bearings if the shop had reamers with which the same work could be done in fifteen minutes and a standard hole made.[2]

Where it would take one hour to turn a driving brass with an old-style flange and nut mandrel, three of them could be done in the same time by using a mandrel with set-screws to locate them in position, and thus not require truing up, and cupped set-screws to hold them tight.

A special chuck for shoes and wedges, whereby the work could have the benefit of all the heads on a planer at once, would be the means of reducing the time by at least one-half over the method of using only one head at the time.

It would not take one hour to cut off a set of piston packing rings if the shop had a gang cutter, whereby the same work could be done in ten minutes.

These are but a few examples of the many cases that could be cited from actual experience to show the difference between a shop with an

[1] See description of Standard Crosshead Reamers, p. 150.
[2] See description of Standard Knuckle Joint Reamers, p. 78.

FIG. 1—PHOTOGRAPH SHOWING A SPECIAL ECCENTRIC JIG AND MILLING ATTACHMENT FOR SLAB MILLING MACHINE FOR FINISHING JOINTS OF ECCENTRIC HALVES. BY THIS METHOD THE TIME FOR FINISHING THE JOINT OF ONE ECCENTRIC HALF WAS REDUCED FROM 1 HOUR AND 45 MINUTES TO 20 MINUTES.

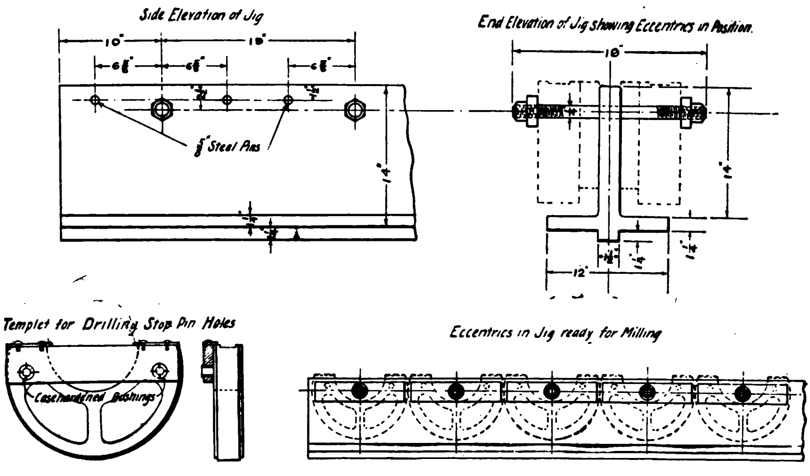


FIG. 2—ELEVATIONS AND GENERAL PLAN OF SPECIAL MILLING JIG FOR FINISHING THE JOINT ON ECCENTRIC HALVES. THE CASTINGS ARE HELD IN THE PROPER POSITION BY STEEL PINS INSERTED IN HOLES DRILLED IN THE ECCENTRIC HALVES A DRILLING JIG INSURES ACCURACY IN THE LOCATION OF THE HOLES.

FIG. 3—SPECIAL CHUCK FOR PLANING 12 SHOES OR WEDGES AT ONE TIME AS SUGGESTED BY CHIEF SHOP PIECE WORK INSPECTOR FOR CHEAPENING THE PRICE OF THE OUTPUT.

equipment of modern tools and one in which the tool-room end is not given the fullest attention. A closer standardizing of parts, made possible by complete sets of reamers, drilling-jigs, templates, etc., for certain lines of work, such as rod knuckle-joint pins, crosshead pins, etc., would be the means of removing an immense amount of extra labor time, worry and inconvenience, to say nothing of the great reduction of maintenance.[1]

Standardization of Tools and Parts.

It is possible to replace a broken part of a bicycle, automobile, typewriter, etc., of any of the standard makes, by simply sending to the factory and specifying only the number and names of the parts required. Why should not this be true, to a great extent, also, of locomotives? Just imagine the great saving it would bring about, and resulting improvement in all departments if any roundhouse foreman along the line were able to send to headquarters for any broken part and know for a certainty that it could be applied without many hours of fitting.[2]

The question is, however, how can this state of affairs be best brought about? In the first place, a complete set of jigs and templates should be kept on hand by the tool-room foreman for all vital parts of the running gear, rods, etc., that are more liable to become broken or thrown out of place; by this effort, duplicate parts are made possible. Then an accurate record should be kept of all of these; they should be catalogued, indexed, and filed in such a manner as to render it possible for anyone, even a stranger, to walk into the tool-room and find easily and quickly anything he might want in this line. When new classes of engines are bought it should be the tool-room foreman's duty to see that the equipment of jigs is brought right up to date for all these new appliances.

With an accurate and complete set of jigs and templates, duplicate parts could always be kept on order. This is the main point—to be able to furnish the parts. The application is of secondary importance. In order to do this with the greatest hope of success, however, the scope of the tool-room should be enlarged. It should not only embrace the making and keeping of labor-saving devices, standard measuring tools, etc., but under its jurisdiction should come the tempering, drawing, hardening, annealing, etc., of all the drills, taps, reamers, etc., that are needed in this department.

Practical Tool-room Methods.

[1] See Standardization of Small-Tool Equipment, p. 139.
[2] See p. 82 for Methods of Standardization and List of Standard Locomotive Parts.
[3] See Templates, illustrated and described on pp. 17, 76.

This should be so, for the reason that it is much easier and far more certain for the man who has watched and worked up a piece of steel, from the rough forging to the finished article, to be able to tell how it will set in the fire than it is for the man at the fire who has had no chance to observe the peculiar properties of this certain piece through its different stages of transformation. This is not idle talk nor mere theory, for it is an established fact that even among the same makes of steel there is always a certain amount of variation as to its action and development. Each individual tool has to be handled as a separate and distinct piece, to get the very best results, and the only sure way to tell accurately how to handle it is to watch it closely from the start to the finish.

Centralized Manufacture of Standard Parts.

As far as possible, all manufactured parts should be made on the place, presumably at the largest and best equipped plant on the system. This would enable one set of jigs and standards to do all the work, and thereby do away with the greater or less liability of mistakes. It is not possible, however, to do this in all things, and duplicate sets of jigs should thus be kept at the most important points. This would require a man to look after these equipments and see that they were kept exactly the same at all points, something in the same manner that all the manufacturing concerns in the country keep up their gauges. They, as a rule, have a man or a number of men who do nothing else but see that the gauges are kept to an accurate standard; in fact, they have this work systematized to such a point that in many of them the temperature of the gauge-room is never allowed to vary from one year's end to another.

Supervision of Standards.

There is no necessity of this, however, on a railway system, in general repair work, as this work does not require anything like this degree of accuracy. This work can be done by some one in connection with other work. A good, all-round practical man would fill the bill, whose duty it would be to see that these templates, jigs, etc., not only are kept up to an absolute standard, but that they are used in shop practice to the best advantage. He should, in fact, be a man who could not only maintain and apply these ideas, but could also create and develop new ones as the occasion required.

In connection with this work, he could see that the tool steels are handled to the best advantage, not only in the actual use on the machine, but in the storing, keeping, checking, tempering, grinding, etc.

FIG. 4—CYLINDER, CYLINDER HEAD AND STEAM CHEST JIGS FOR DRILLING STUD HOLES ACCURATELY FOR INSURING INTERCHANGEABILITY OF PARTS.

The writer has been in shops where a special high-speed steel was being used that cost 70 cents a pound, and the shop was not getting any better results than when using the old carbon steels. This was due simply to the fact that there was no one there whose particular duty it was to look after this; some of the men in charge did not know and some did not care, and so the thing went on, with no good results for anyone, and only added expense to the company.

In this connection, the question can be asked, and very properly, too: Of what use is an up-to-date tool system if it is not kept up? The answer is emphatically, None! But another question can also be asked, and that is: What reason is there that it cannot be kept up? And the answer is, also—None! The only thing that needs a remedy, and, in fact, the only weak spot possible in a modern and up-to-date tool system, is lack of interest or lack of knowledge among those directly connected with it. In most cases the lack of knowledge is responsible for the decline of a tool system.[1]

High-speed Steel in Railroad Shops.

It is admitted by all interested that in the last decade no such remarkable change of shop methods and appliances has been brought about by any one movement as by the introduction of the new high-speed steels. The changes are so great and so many that it is impossible for the best of foremen, let alone the average of the rank and file, to keep pace with the movement and see that everything is keyed up to the point where it is possible to always obtain the best results. In the present every-day run of railroad life, a master mechanic, a general foreman, or even a machine shop foreman, has entirely too much to look after to allow him to devote sufficient time to the tool or steel end of his department.

The Shop Demonstrator.

What is needed to overcome this difficulty is a demonstrator or teacher, a man who not only possesses the necessary knowledge, but also the ability to impart it. This man should work hand-in-hand with the tool man, and it should be his duty to see that all new tools are thoroughly understood by everybody who will be called upon to use them. He should go from shop to shop as any new tools are introduced, and see that they are worked at all times to the best advantage. He should see that the best methods are adopted for tempering, handling, and applying all steels, and that all tools are kept up to the proper capacity.

[1] See article, "Care and Control of the Small-Tool Equipment in the Shop," by R. Emerson, in Engineering Magazine, February, 1905.

Without going into more elaborate detail, and without touching on one of the greatest of all the problems, labor, it can be said without fear of contradiction that the above fairly well covers the ground of the many improvements that could be inaugurated by placing the tool end of a railroad shop on an equal basis with that of a manufacturing concern.

Widen the scope of each tool-room locally till it embraces everything that properly belongs to its department; then see that the tools along the line are kept checked up together; and the results will be beyond the most sanguine expectations. The motive power will be brought nearer a universal standard; the working method of the entire system, as far as the shops are concerned, will be placed on a sure and accurate basis, and the saving thereby brought about will be far greater than can be possible in any particular line of shop practice.—H. W. JACOBS, *in American Engineer and Railroad Journal, May, 1904.*

IMPROVED DEVICES FOR RAILROAD SHOPS.

Example of Progressive Shop Policy.

WHILE it may be said that railroads generally have been slow to adapt modern methods to locomotive erecting and machine work, a visit to the Omaha shops of the Union Pacific will show that one railroad, at least, has realized the economical advantages of a progressive shop policy. The machine tools are driven by direct-current motors-and more than 60 per cent of the tools are new. Good results were obtained, but it was realized a year or more ago that possibilities for a considerable improvement in efficiency existed. It was decided to put the matter into the hands of one man who would devote his entire attention to bringing each important tool up to its maximum service. In some cases the output of a single tool has been so greatly increased that extra tools, previously needed, have been withdrawn from service. A few of the more notable and interesting records are given in the following:

Machine Practice and Production Records.

Three pairs of 50-in. Midvale tires, which were badly worn, required two roughing cuts and were finished in 4 hours and 4 minutes, the first pair taking 1 hour and 40 minutes, the second pair 1 hour and 37 minutes, and the third pair 1 hour and 27 minutes. This includes all work from the time the wheels were taken off of the floor until they were put back again. The machine used was a 90-in. Pond lathe driven by a 15-h.p. motor. The average surface speed was 23 f. p. m., using a 3/16-in. cut and feed. The maximum power demand on the motor was 7 h.p., and the average horse-power was 4½. On the basis of these tests the horse-power of the driving motor could be reduced about one-third and still have enough power to do the work.

Turning Driving-wheel Tires.

On this same lathe 84-in. drivers having Standard tires were turned at a peripheral speed of 28½ f. p. m., using a 5/16-in. cut and 3/16-in. feed. With these heavy cuts and feeds and high cutting speeds, a tendency to excessive vibration is developed in the machine due to the dogs being too light and the shaft too small, and an uneven chattering motion given by the large gears. Larger dogs have been designed at the shops for the purpose of reducing the trouble. It has been suggested that these difficulties can be overcome by doing away with the driving shaft, which is subjected to considerable torsional stress, and drive each face plate independently with a worm.

Before high-speed steels were introduced into the shops, car-wheel tires required 5 hours for turning. This time has now been reduced

Turning Coach-wheel Tires.

to 55 minutes, the machine having been speeded up to a cutting speed of 28 f. p. m., as against 6 ft. formerly. The feeds and depth of cut have, of course, been increased correspondingly. The lathes proved to be too light in some respects for this heavier service, and they were strengthened by replacing the cast-iron pinions with soft steel.

Roughing Piston Rods.

Extended piston rods are finished from the rough forging in 7 hours. The former time was 14 hours. The average roughing speed is 5 f. p. m. with ¼-in. cut and a 3/16-in. feed. This work is done on an old New Haven 36-in. lathe that has been in service thirty years. The finishing is done on a new 38-in. Pond lathe at 90 f. p. m.[1]

Turning Piston Valves.

The time on piston valves has been reduced from 14 hours to 3 hours. This includes centering and turning valves of medium hard cast iron 12 in. in diameter. The work is done on a Lodge & Shipley 36-in. lathe. Roughing is done at 38 f. p. m. with a ⅜-in. cut and a ¼-in. feed. Finishing and grooving is done at 45 f. p. m.

Turning Cylinder Bushings.

Low-pressure cylinder bushings 30 in. in diameter are turned in 1 hour and 40 minutes on a 42-in. Pond lathe. A year ago this job took 12 hours. The speed is 32 f. p. m. with a ½-in. cut and a ¼-in. feed. The finishing cut is at 48 f. p. m. with a 1-in. feed. This includes turning and facing complete, "floor to floor."[2]

Drilling Flue Sheet Holes.

The record for drilling flue sheets has been increased from 30 to 110 holes an hour. This has been accomplished by means of the cutter shown in the accompanying sketch, Fig. 5, which was designed at the shops.[3]

Wheel Lathe Tools and Holder.

The tool used for turning the flanging locomotive and car-wheel tires is shown in Fig. 6. It consists of a cast-steel holder having at one end the roughing tool and at the other the flanging tool, both being made of high-speed steel.[4]

Raising Air Drums.

The old method of blocking up air drums by means of wooden blocks is shown in Fig. 7, and as a substitute for this antiquated and costly method, the air hoist shown in Fig. 8 was devised. The hoist consists of a 5-in. air cylinder supported upright in a frame work on three wheels provided with a tongue. The details of construction will be seen in Fig. 9. The upper end of the piston rod is shouldered and threaded and carries a cradle in which the drums are placed. The rod carries a split collar which rests on the upper head of the cylinder, which is used to secure the rod at any height.

To overcome the necessity of machining the sliding surfaces of the crossheads of the Vauclain compounds a cast-iron jig (Fig. 10) is used.

[1] See p. 43 for improved methods in turning piston rods.
[2] See p. 124 for improvements made in design of cylinder bushings and the reduced cost of turning.
[3] See p. 86 for photograph and description of flue-sheet cutter.
[4] Illustrations of tool-holder and tools and saving in steel by its use, shown on p. 115.

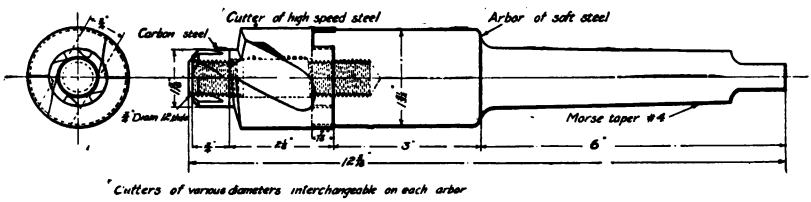


FIG. 5—FLUE-HOLE CUTTER WHICH HAS A CAPACITY OF OVER 100 HOLES AN HOUR. DESIGNED BY A SHOP DEMONSTRATOR.

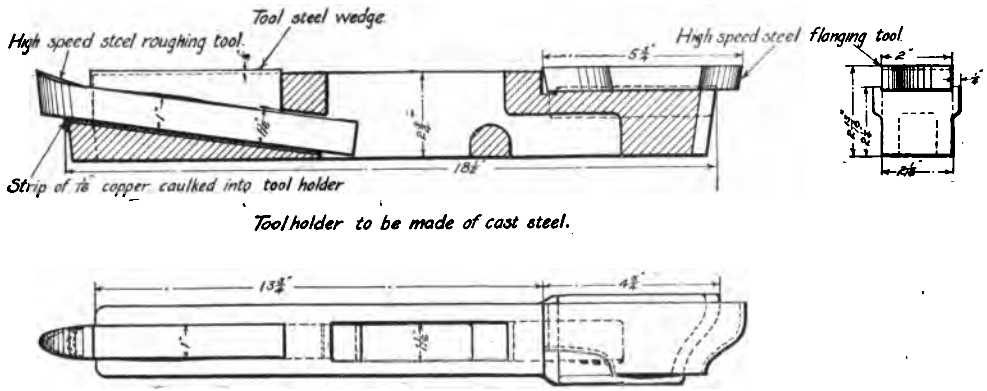


FIG. 6—CAST-STEEL TOOL-HOLDER FOR WHEEL LATHE, TIRE TURNING AND FLANGING TOOLS, DESIGNED BY A SHOP DEMONSTRATOR.

FIG. 7—OLD METHOD OF RAISING AIR DRUMS TO POSITION BY BLOCKING UP WITH WOODEN BLOCKS. TIME REQUIRED TO RAISE DRUM TO POSITION AS SHOWN, 2 HRS. AND 45 MIN., FOR 2 MEN.

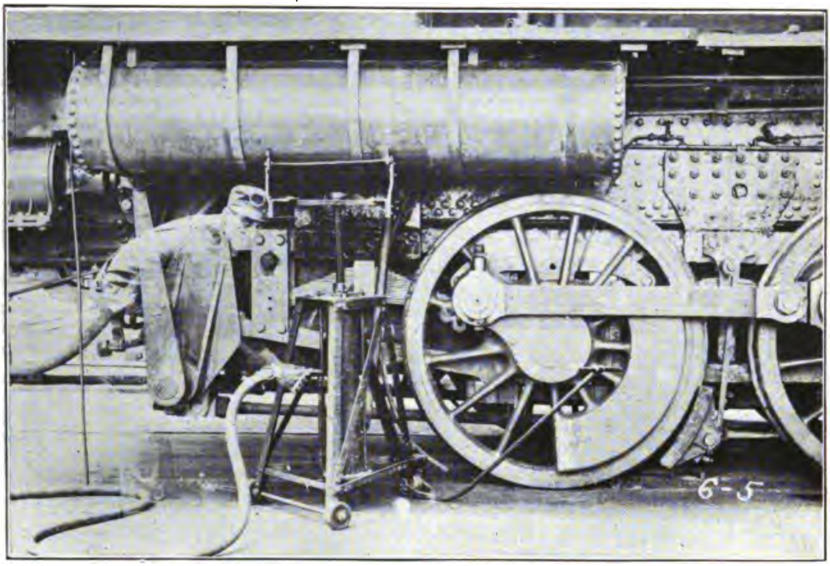


FIG. 8—PNEUMATIC AIR HOIST FOR RAISING AIR DRUMS. ONE MAN WITH THIS DEVICE WILL RAISE A DRUM TO POSITION IN 1 HR.. THUS SAVING 2 HRS. AND 30 MIN. OVER THE OLD METHOD.

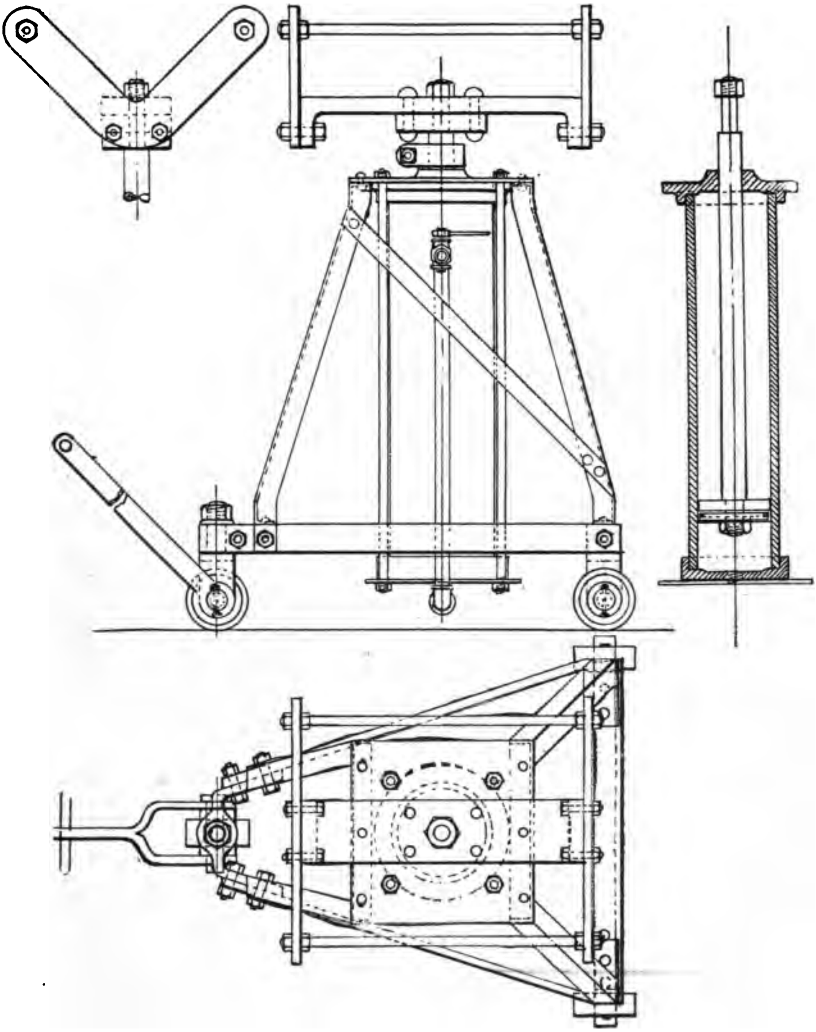


FIG. 9—ELEVATIONS AND SECTION OF PNEUMATIC AIR DRUM HOIST.

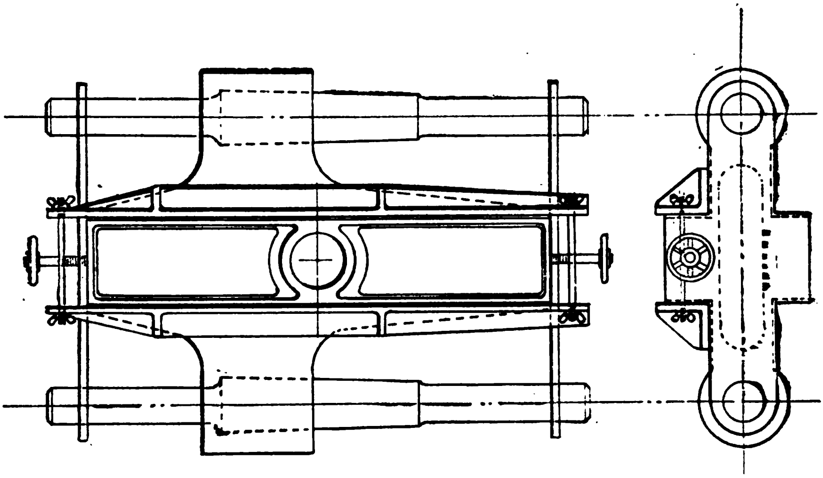


Fig. 10—Side and end elevations of jig for babbitting crossheads of Vauclain compound locomotives, avoiding the necessity of machining the babbitt bearing faces.

It consists of two end-plates made of boiler plate, which are supported by two soft-steel mandrels, each having a taper part to fit the piston rod fit of the crosshead. The end plates support four cast-iron angle face-plates in the same position relative to the crosshead as the guides. The top and bottom angle-plates on each side are clamped together and hand wheels with threaded stems, inserted through the clamps, bear against the end-plates, holding the angle-plates rigid longitudinally. The crosshead is heated in a molten babbitt bath contained in a cast-iron box, and the end-plates and mandrels are heated to a uniform temperature. The resulting babbitted surfaces are of such smoothness that after a short time in service their condition is as satisfactory as if they had been milled or planed, while the time for this later operation, amounting to 1½ hours per crosshead, is entirely saved.

Crosshead Jig.

The method of milling ports in piston valve bushings for compound engines is shown in Fig. 11. This is done with a specially designed fixture, which mills four ports at once.[1]

Knuckle Pin Hole Reamers.

By the use of knuckle-pin reamers the time for reaming rods has been reduced from 2 hours to 15 minutes. In connection with the reamers is a set of templates which have been reamed out, hardened and ground, to which the reamers have been sized. The different shops along the line have been supplied with reamers, but the templates are kept in the Omaha shop, each hole having a symbol number corresponding to the reamer that has been fitted to this hole. All knuckle pins are made at Omaha, and any point along the line wanting a certain pin simply gives the symbol number.[2]

Air Brake Work.

Twenty triple valves are completely overhauled in a day of nine hours by one man and an apprentice. Fig. 12 is a corner of the brass-room where triple valve work is done, showing the rack for testing the valves. One man grinds 7 angle-cocks in 35 minutes. This is done on a special grinding machine (Fig. 13) that has been built up out of a nut tapper rescued from the scrap bin.

Planing Shoes and Wedges.

All shoes and wedges for the entire system (about 3600 per year) are planed on a Pond machine. The time is 30 minutes per shoe or wedge, planing the surface on five sides. A special chuck was devised for this work. With a special adjustable chuck, driving-box brasses are turned to fit ~~the box (for a 9-in. journal) in 15 to 20 minutes. For former time was~~ 1 hour.[3]

Milling Eccentrics.

Eccentrics, cast-iron, in two halves are planed up with a special jig for clamping them on the planer, at the rate of six halves an hour. The former time was two halves an hour. They are turned on a special mandrel holding four at one

[1] See pp. 97–98 for comparison of old and new methods of milling the ports in piston valve bushings.
[2] Illustrations of standard knuckle-pin hole-reamers shown on p. 79.
[3] See p. 14 for illustration of special shoe and wedge-planer chuck.

time (Fig. 14) at the rate of one hour each. The former time was two hours each.[1]

The former record for boring cast-iron car wheels was 50 in nine hours by one man. There is now a record of boring 90 wheels for a

Boring Car Wheels.

5½-in. fit in this same time, by one man, on two boring mills, using high-speed steel cutters. With a double angle-iron for clamping, and a double tool-holder, eight new driving boxes have been planed up complete in 14 hours. The time with old methods was 5 hours per box.

Special Machine Records.

One specially belted planer, to plane steel rods, runs 52 f. p. m. and removes, on actual test, 846 lbs. of metal per hour.[2]

Eighty two-in. steel tires are bored and faced (¼-in. stock removed) in 35 minutes. The old time with the old steel was three hours.

On a Gisholt lathe, fitted up with high-speed cutters, forty 4-in. cast-iron piston-rod glands have been fitted up in nine hours.

On a new 24-in. Pond lathe, sixty 13-in. valve packing rings have been bored, faced and cut off in six hours.

A special double tool-holder for slotter work enables the operator to slot out a large steel driving box complete for brass and cellar fit, in 1½ hours; old time, 3 hours.

A special revolving angle-iron chuck, with which the brass needs but one cutting, enables the operator to plane for the rod fit a large back-end main rod brass in 2½ hours. The time by the old method was five hours.

Other aids to rapid handling of work are the regulation of the crane service, and the narrow-gauge track system. For instance, there is used with the crane a form of tackle which permits of four driver boxes being picked up and carried with safety at one time.[3] Material is stored in special places on the platforms, and all refuse, chips, scrap, etc., are placed in bins provided for each, these bins being emptied periodically. The narrow-gauge road for the most part runs by a time-table.

The present efficient condition of these shops has been brought about under the supervision of W. R. McKeen, Jr., superintendent of motive power and machinery, to whose suggestions many of the special methods and devices in use are due. H. W. Jacobs, general shop demonstrator for the Union Pacific System, has been directly in charge of the work.—*Notes by an editor of The Railroad Gazette, June 24, 1904.*

[1] Special jig for milling eccentric halves shown on p. 13.
[2] See pp. 48, 49, 51 for illustrations and description of re-designed planer for high-speed tools.
[3] See p. 157 for illustration of a driving-box sling of similar design.

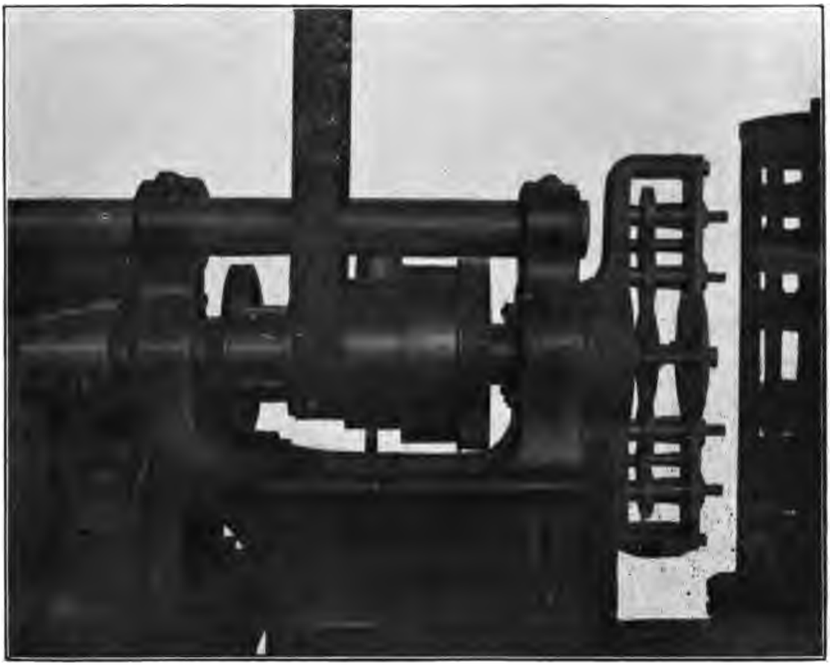


FIG. 11—SPECIAL DEVICE FOR MILLING MACHINE, ENABLING FOUR PORTS IN PISTON-VALVE BUSHINGS TO BE MILLED SIMULTANEOUSLY, DEVISED BY SUPERINTENDENT OF SHOP.

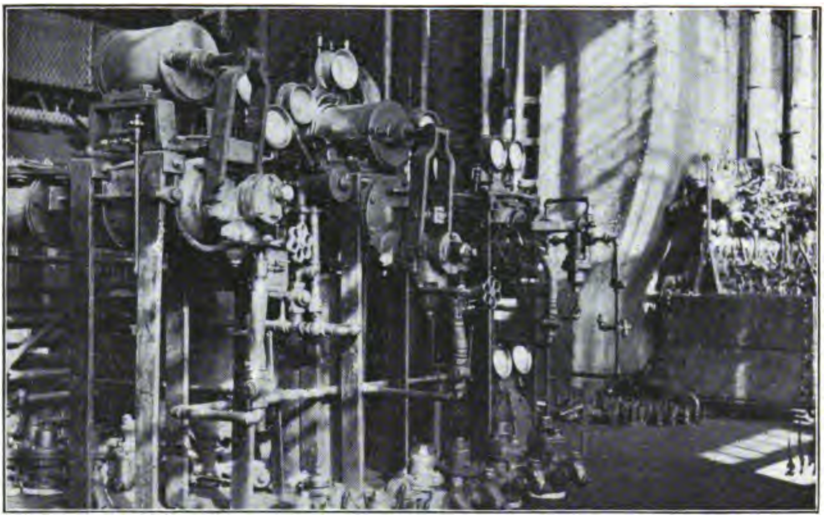


FIG. 12—CORNER OF AIR ROOM SHOWING RACK WHERE ALL TRIPLE VALVES ARE TESTED FOR A RAILWAY SYSTEM.

FIG. 13—ANGLE-COCK GRINDING MACHINE ON WHICH ONE MAN GRINDS 7 ANGLE COCKS IN 35 MINUTES. CLOSE INSPECTION OF THE ILLUSTRATION WILL SHOW "PHANTOM" ANGLE COCKS IN PLACE. DEVISED BY GENERAL FOREMAN.

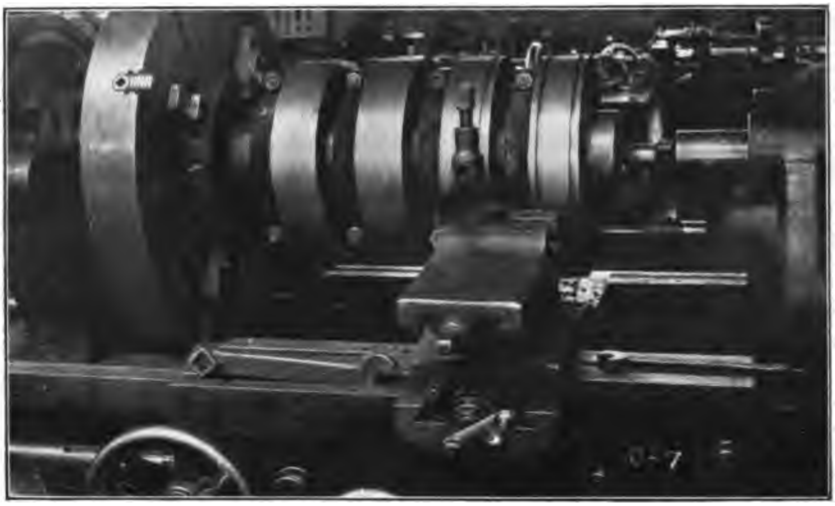


FIG. 14—SPECIAL MANDREL FOR TURNING 4 ECCENTRICS WITHOUT CHANGING MANDREL. TIME OF TURNING ONE ECCENTRIC WASREDUCED FROM 2 HOURS TO 45 MIN. BY THIS DEVICE.

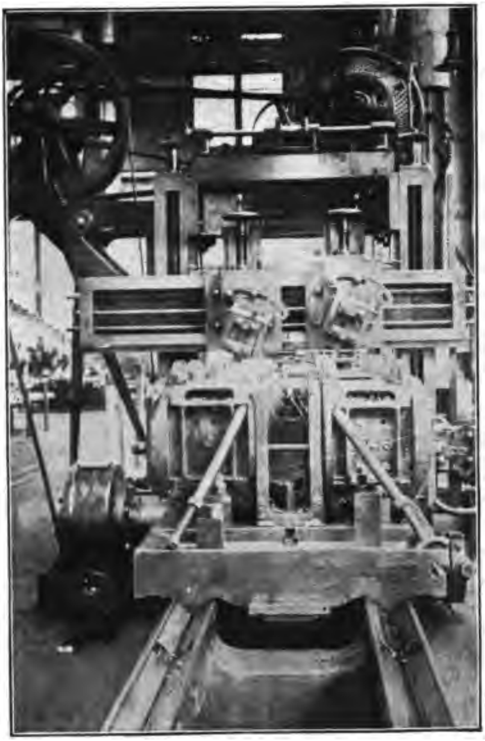


Fig. 15—Planer with driving-box jig and attachments for planing two rows of driving boxes at one time.

HIGH-SPEED STEEL IN RAILROAD SHOPS.

As a result of extended observation and considerable experience in handling the new steels and applying progressive methods in connection with them, I would lay it down as a cardinal principle that before any attempt is made to put in so radical a factor of increased production as the new high-speed steel, the fullest attention should be given to the machine end of the plant, and to the methods in vogue at the place where these steels are to be introduced. No amount of steel, bought out of hand, is going to revolutionize the manner of doing the work; and mere purchase of expensive grades of steel will not cheapen the cost of production. Even if the new tools are being introduced by men who understand them thoroughly and who exercise energy in applying them to practical work, the result will not always be up to expectations, and a host of unsuspected and discouraging evils will be brought in.

Preparations necessary before Introducing Alloy Steel.

In the first place, the majority of machine tools in railroad shops today are not designed or built to stand the service that the high-speed steel would demand of them. To introduce these steels in the ordinary course of events will often prove disastrous to the machines (Fig. 81), if these are speeded up or worked with heavy cuts, unless proper safeguards are taken. The depreciation rate becomes much greater under the new condition than under the old; but with proper management it will be found profitable to do this when the increased production capacity is realized.

The most difficult factor to deal with, however, when there is not the whetting of competition (as in the case of commercial shops) to force the management to be vigorous in prosecuting improved methods, is the attitude of the men, who have grown used to the old ways, and who view with hostility and suspicion any innovation of this character.[1]

Difficulties to be Encountered.

Unless a director of methods or demonstrator is employed, whose special duty it is not only to direct how the tools shall be made and used, but also to keep the men up to the new cuts and speeds, the great majority of the men will be most loath to maintain the increased pace

[1] The practical value of the shop demonstrator, p. 19.

that the new steel necessitates in order to be a paying proposition. To get around this difficulty the writer has found it an excellent plan: First, to examine the machines as to their capacity of standing the increased service, to remedy what defects might be found (Fig. 16). Then immediately to increase the speeds, by changes in pulley sizes on both main and countershafts, so as to have the machines in general running at a rate of speed much above that used with the older tool steels.

Increase Machine Speeds.

These speed increases may vary from 30 per cent to over 200 per cent above the original speed. They are not attained by one jump, but by a succession of judicious increases, gradually getting the men used to the higher speed, to a busier hum of pulleys and machines, to a greater rapidity in turning out the work. By making these changes (Figs. 18, 20 and 84), and at the same time following up the matter of proper use of cutting tools, with proper feeds and cuts, the men are induced, almost unconsciously, to fall in line with the new methods. One very essential point, which should not be overlooked, is that every tool of the older steels should be withdrawn from the shop entirely, and high-speed tools substituted, so as to prevent any tendency to cling to the old ways of doing things.

Not only do the mechanics object to innovations, but the gang foremen, foremen, and general foremen even, do not accustom themselves readily to the new conditions. For it must be remembered that the foreman of a shop, more particularly of a railroad shop, has so many duties devolving upon him that he does not, as a rule, have sufficient time for looking after a new move of this kind. The introduction should, therefore, be in the hands of a man whose whole time can be devoted to the handling of the new tools. This man should be a thorough mechanic, well informed as to the care and working of these steels, and of sufficient inventive ability to devise quick methods and ways of economizing work. He should also possess the knack of being able to get along with the workman with a minimum amount of friction, for the attitude of hostility before mentioned is never so much in evidence as when the man who is responsible for these changes is actively engaged. And he should stimulate the foremen with whom he is working, to advance ideas, such as that shown in Fig. 37 (for which full credit is given when successful), even to a spirit of rivalry with himself in the introduction of time-savers.

Opportunity for Shop Demonstrator.

Yet the individual capacity and tact of this demonstrator will not

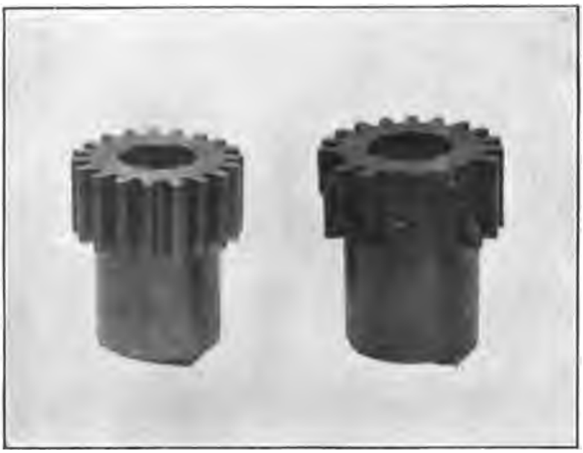


FIG. 16—STEEL PINION FOR COACH WHEEL LATHE TO REPLACE ONE OF CAST IRON THAT WAS NOT STRONG ENOUGH TO STAND THE HEAVY CUTS TAKEN WITH HIGH-SPEED TOOLS.

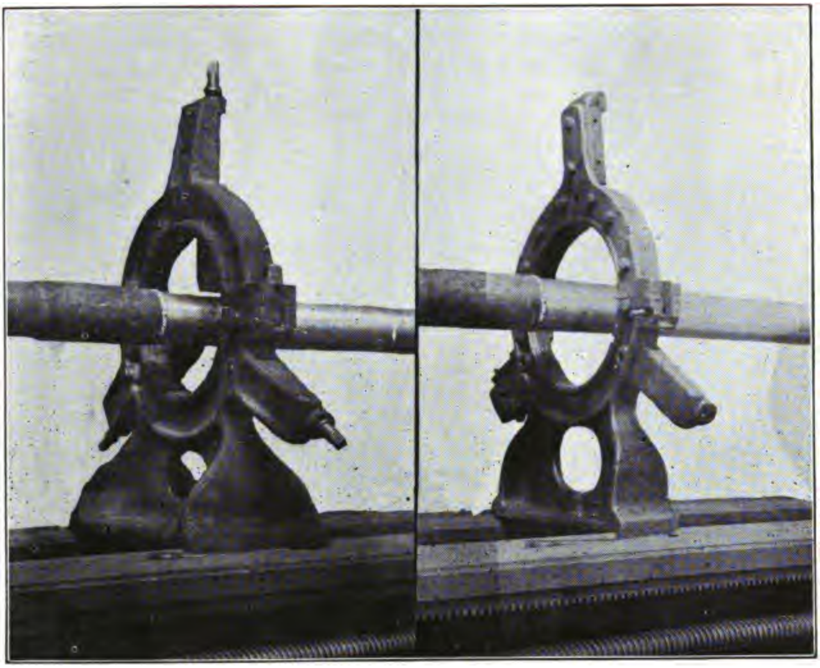


FIG. 17—RE-DESIGNED STEADY REST FOR LATHE AND OLD DESIGN THAT WAS NOT STIFF ENOUGH TO SUPPORT THE ROD UNDER THE HEAVY DUTY IMPOSED ON IT BY HIGH-SPEED TOOLS.

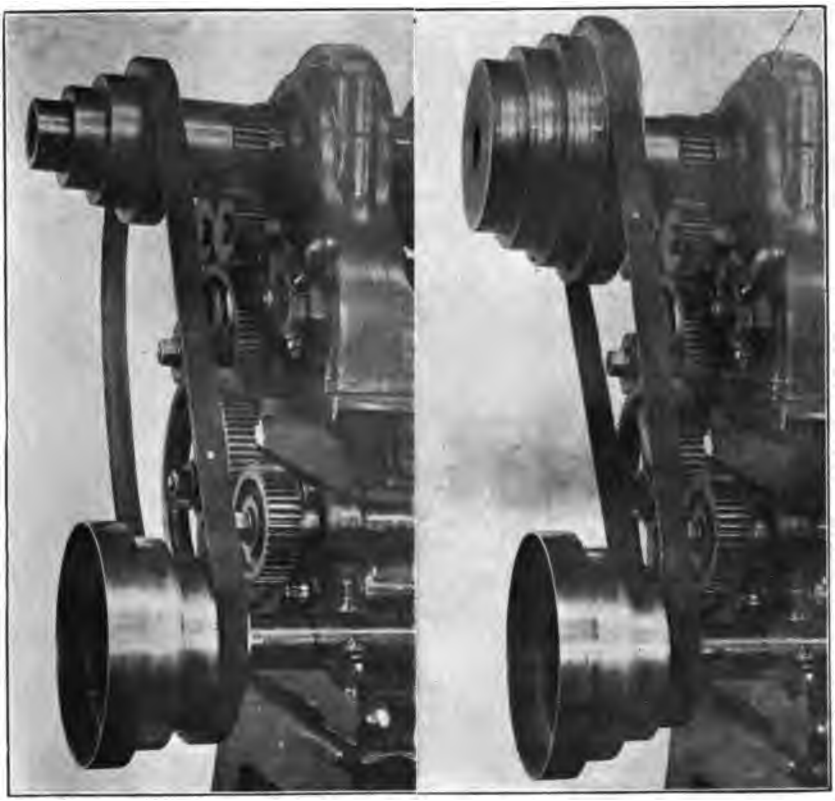


FIG. 18—FEED CONE PULLEY FOR LATHE, RE-DESIGNED TO INCREASE THE CAPACITY OF THE MACHINE UP TO THE FULL CAPABILITIES OF THE HIGH-SPEED TOOL STEEL.

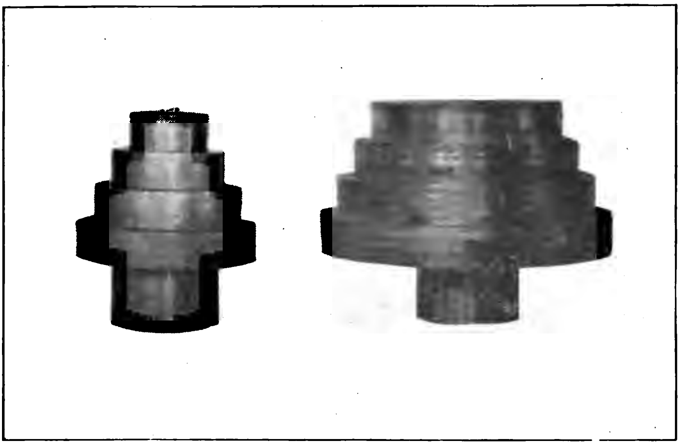


Fig. 19—Photograph showing relative sizes of old and new feed cone pulleys of a lathe transformed for use with high-speed steel.

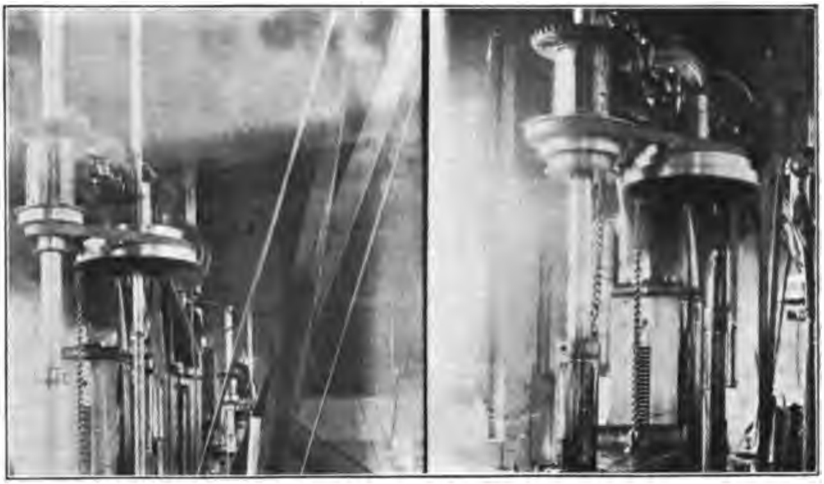


FIG. 20—VIEW OF DRILL PRESS SHOWING CHANGES IN FEED CONE PULLEYS, DUE TO THE USE OF HIGH-SPEED DRILLS.

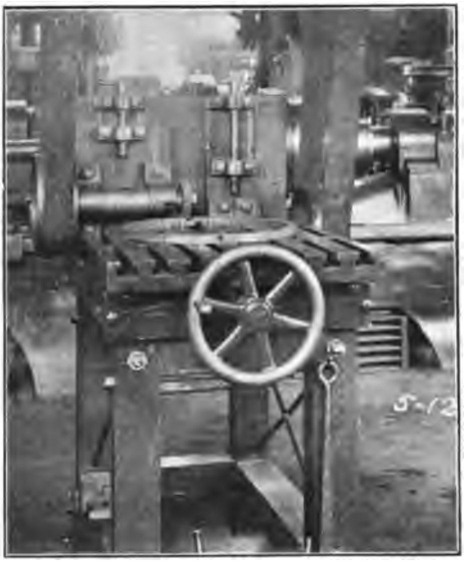


FIG. 21—SNAP RING MILLING MACHINE DESIGNED BY A MACHINE FOREMAN AND BUILT LARGELY FROM PARTS OF OLD MACHINERY. TIME FOR MACHINING ONE RING, 35 SECONDS.

alone meet the problem. Unless full support is given by the superintendent of motive power himself, unless it be well understood that he intends making a success of the new methods, and it be shown from time to time, by personal talks with the more influential foremen, and in other ways, that these innovations are no mere vagaries of an unpractical man who is only "on trial," the progress of improvements will be hampered at every turn. Moreover, as the chief attention of the demonstrator will be required in the shop so as to keep the new methods moving, he should be afforded the use, when necessary, of draughtsman and stenographer, as it will not pay to have him spend his time over the drawing-board, or in writing out, longhand, whatever communications he needs to make.

Responsibility of Higher Officers.

These are the main points to be considered in the introduction of the new alloy steel tools, or rather the obstacles to which chief attention must be given and which must be overcome before any permanently beneficial results can be obtained. As to the results themselves, no better evidence may be given of what can be accomplished than to cite examples of what has been done in a shop where these principles have been adhered to. When the new steel tools were first announced, extensive tests were made in this shop of all brands that could be secured, and steps were taken to secure a man who could direct their introduction. While, of course, the superintendent of motive power could not devote time and attention to each little detail, yet he directs in a large and farsighted way the lines it would pay best to follow, and it must be acknowledged that without his interest no such degree of success could be attained. I need only add that the cases that follow are not special record ones (as was that of turning a pair of 68-in. driver tires in 1 hour and 31 minutes), but are typical of everyday performance. The same character of results has been attained in hundreds of other such jobs.

Extended Piston Rods.—These rods (Fig. 22) were rough-forged in the blacksmith shop. The time for complete turning, threading, fitting, etc., under the old conditions, was 14 hours. When the new steels were put in, the man on this work was supplied with an outfit of tools and instructed to get the most he could out of them. The best time he made was 12 hours, but even this did not always keep up when the man was left to his own resources. This reduction in time was obtained by using a faster step on the cone pulley, and by increase in the depth of cut. However, as it was rather inconvenient to make

the belt changes, the man preferred to run at a slower rate. The matter was then taken hold of by the demonstrator and a number of changes were made. First, the work was divided between two lathes, one for rough turning and one for finishing. The lathe for rough turning was an old one, but was put in shape, fitted with steady rests (see Figs. 17 and 23), etc., and adapted for turning roughly to within $\frac{1}{32}$ in. of finished size. The pulleys on main and countershafts were changed, making a speed increase of from 140 to 320 r. p. m. This maintained the higher turning speed even on the lower cone pulley step. A second-year apprentice was used on this part of the work, replacing the more conservative machinist, and he was induced to use the higher step at the cone pulley. The peripheral speed of the work was thereby changed from 20 ft. to 65 ft. per minute. On rough turning the depth of cut was doubled, thus finishing a rod with only one heavy roughing cut instead of two. The feed was increased from $\frac{1}{16}$ in. to $\frac{5}{32}$ in. The total time of rough turning under the new conditions was, therefore, $\frac{1}{3\frac{1}{4} \text{x} 2 \text{x} 2\frac{1}{2}}$, or about 1-16th of the former time. This is for actual rough cutting. The former time of complete rough turning was two hours and fifteen minutes, to which must be added one hour and three-quarters for setting work, etc. Under the new conditions, although the actual rough cutting time was reduced to about ten minutes, the complete time of rough turning was one hour and a half, the additional hour and twenty minutes being the sum of all the times necessary to turn the rod end for end, apply and take down chucks and dogs, rough turning taper and collar, threading, grinding tools, etc. In other words, the ratio of cutting time to total time was greatly reduced. The black-line diagram, Fig. 24, illustrates where the saving was effected.

Modern Methods Applied to Finishing Piston Rods.

In the finishing process similar methods were employed, with similarly gratifying results, although here the principal time-savings were by methods and not by high-speed steel; so that, all in all, the time reduction of six to seven hours on this one job was due as much to intelligent modification of the conditions under which the new steels were to act as to the steels themselves.

Reduction in Time of Turning Coach Wheel Tires.

COACH WHEEL TIRES.—Another example is that of the time on one pair of steel-tired coach wheels, where a reduction was made from five hours to one hour. As in the previous case, increase in pulleys, thus permanently increasing wheel-lathe speed, and other changes, such as special designs

FIG. 22—EXTENDED PISTON RODS ON WHICH THE TIME FOR FINISHING COMPLETE WAS REDUCED FROM 14 TO 7 HOURS BY APPLYING MODERN METHODS.

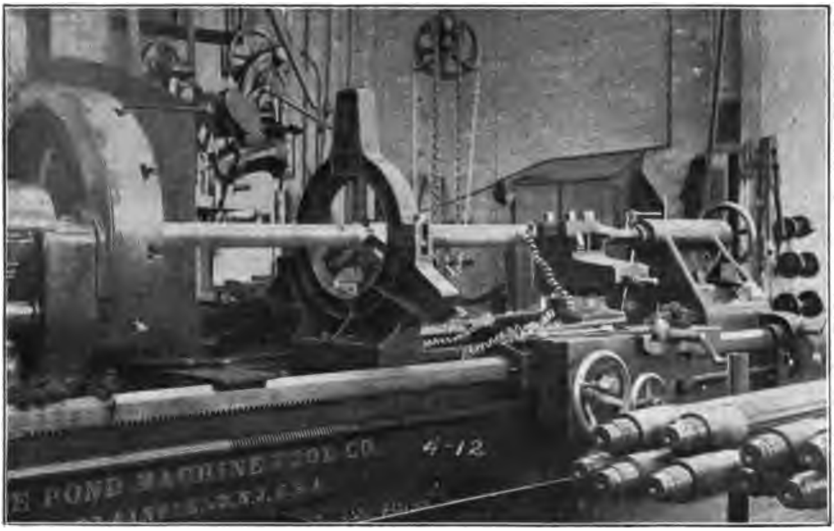


FIG. 23—TURNING EXTENDED PISTON RODS IN LATHE EQUIPPED WITH HIGH-SPEED TOOLS AND APPLIANCES.

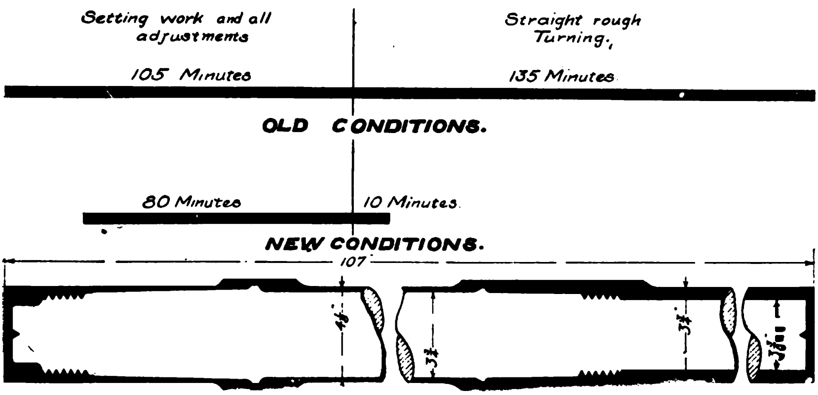


FIG. 24—SECTION OF EXTENDED PISTON ROD SHOWING METAL REMOVED (IN BLACK) FROM ROUGH FORGING, AND TIME TAKEN FOR ALL OPERATIONS UNDER BOTH OLD AND NEW CONDITIONS.

FIG. 25—COMPARISON OF OLD AND NEW DESIGNS OF WHEEL LATHE TOOLS, SHOWING THE WAY TO ECONOMIZE IN THE AMOUNT OF HIGH-SPEED STEEL USED. THE TOOLS FOR USE WITH CAST-STEEL TOOL-HOLDER REPLACE THE SOLID TOOLS WEIGHING NEARLY TEN TIMES AS MUCH IN TOOL-STEEL.

Fig. 26—Views showing increase in size of driving pulley on planer for increasing the planer's cutting speed in connection with the use of high-speed tools.

FIG. 27—VIEW SHOWING PLANER AND NEW 20 H. P. MOTOR WHICH SUPPLANTED A 10 H. P. MOTOR IN ORDER TO PROVIDE SUFFICIENT POWER TO DRIVE THE NEW HIGH-SPEED CUTTING TOOLS TO FULL CAPACITY.

FIG. 28—VIEW FROM ABOVE PLANER BED SHOWING LARGE CHIPS REMOVED BY HIGH-SPEED TOOLS FROM MAIN RODS.

of tool-holders (see Fig. 6), substitution of forged steel pinions for cast iron (see Fig.16), so the machine could stand the increased strain, were all instrumental in accomplishing the desired results.

PLANERS.—Speed increases were made in the principal planers up to a cut of over 50 ft. per minute, or the limit under this heavy work of the tools. One result of this change is a close approach to the reverse speed of the speed of cutting stroke, as nearly the limit of the machine's capacity to overcome the inertia of the table is reached under the changed conditions. Figs. 26 and 27 illustrate improvements in planer practice.[1]

Improved Planer Practice.

If space permitted, numerous other instances could be cited, all taken from actual shop practice, such as turning eccentrics, cylinder bushings, car axles, planing shoes and wedges, etc.

The time on all these was reduced from one-half to one-eighth of former time. The average increase, based on actual output, and the difference in weight of metal removed was:

Cast Iron	120 per cent.
Steel	150 per cent.
Good, clean wrought iron	175 per cent.

CONCLUSIONS.

In conclusion I can but repeat that the buying of high-speed steel is of little use unless progressive methods of application in actual work are employed to effect real reduction in cost, which is the final and only test in the question. In order to introduce these methods it is always better policy to bring into each shop a man who has not been brought up in the traditions of the place, and have him make the changes, the possibility of which would not be seen as rapidly by one too used to the older conditions. A local demonstrator should report direct to the superintendent of shops, or where there is no such position, to the division master mechanic, so that he will have sufficient authority behind him to carry out his plans, and so that general and important interests may not be sacrificed to local and individual preferences. If there were a general demonstrator for an entire railroad system, the local demonstrator should report to him, and he in turn direct to the highest authority in control of the different shops, the superintendent of motive power. Of course, upon the latter person the ultimate success or failure of an enterprise of this kind must rest. So far as I know,

Outline of Organization.

[1] See report of planer tests 1 and 2, p. 54.

Mr. W. R. McKeen, Jr., of the Union Pacific, has been the only, or at least the first, superintendent of motive power who has had the temerity to create a position of this kind, and who has used the force to drive his purpose home. That he has been amply justified is admitted by all who have had the opportunity to see the results accomplished in the shops on his system, not alone in the new Omaha shops, but also in the redistribution of work among all the shops, made possible by the increased capacity and concentration of manufacture in the main shops, and in the economies effected by restricting the smaller and less well-equipped points to repairs requiring light machine work only.—H. W. Jacobs, *in American Engineer and Railroad Journal, September, 1904.*

HIGH-SPEED TOOL STEEL IN RAILROAD SHOPS.

Editorial Comment by American Engineer and Railroad Journal, Sept., 1904.

If busy railroad officers who are at their "wit's end" to know how to meet the conditions of decreased rates per ton mile and increased cost of labor and material will carefully ponder the record presented by Mr. Jacobs in this issue, they will discover one of the roads they need to follow, that of the application of commercial principles to railroad service.

Mr. Jacobs treats of shop practice, and when "16 to 1," the familiar slogan, is applied so successfully to the improvement of shop-tool output, the record is entitled to keen attention by the highest officials of all our railroads. The Union Pacific has become a leader in this movement toward improved shop methods. On cast-iron, the improvement in output has been 120 per cent; on steel, 150 per cent, and on wrought iron, 175 per cent, considering actual results and the weight of metal removed in a given time. Union Pacific practice, before the new methods were applied, was probably neither far better nor far worse than that of other roads. It is, therefore, safe to say that other roads present the same opportunities for improvement. If the statements of Mr. Jacobs receive the attention they merit, a wave of improvement of machine and shop output will pass over the entire country, and this will mean much for the railroads and for the men into whose hands this opportunity falls.

Nearly every shop has the new tool steels, and blue chips are commonly seen. This, however, is not sufficient. Machine tools, men, and shop methods require a new kind of attention. In fact, the new steels have revolutionized shop practice all over the world, and the railroads are suitably encouraged. The railroad mechanical officer will be in position to contribute, as he never has before, to the advancement of transportation, and he will take a high place among the leaders of the times. This officer is ready and willing to undertake his task. The main question lies before the management, the directors and the owners, Shall this opportunity be accepted? It will be accepted, and this journal expects to be kept busy recording the steps in this revolution.

COMPARATIVE COST OF OUTPUT FOR ONE PAIR OF DRIVING WHEELS.

OPERATION.	Carbon. Hrs. Min.	Air Hardening. Hrs. Min.	High Speed. Hrs. Min.	High Speed. Hrs. Min.	Carbon.	Air Hardening.	High Speed.	High Speed.
Setting tool, etc., throughout job	1:30	1	:45	**:36**	$0.50	$0.33	$0.25	**$0.20**
Grinding roughing tool	1:30	1	:20	**:20**	.50	.33	.11	**.11**
Grinding flanging tool....................	1:30	1	:04	**:04**	.50	.33	.02	**.02**
Roughing cut	8	5	1:15	**1:00**	2.65	1.65	.41	**.33**
Finishing cut.	5	2:30	:30	**:30**	1.65	.83	.17	**.17**
Flanging cut...........................	2:30	1:30	:30	**:30**	.85	.50	.17	**.17**
Total labor	20:00	12:00	3:24	**3:00**	6.65	3.97	1.13	**1.00**

Interest, depreciation, repairs, etc., figured at 15% on first cost, per hour	(.13)	(.40)	(.40)	....
per job	2.60	1.60	1.30	**1.20**
Power, at 3 cents per horse-power, hour........................per hour	(.07)	(.12)	(.18)	....
per job	1.00	1.00	.50	**.50**
Total fixed charges.	3.60	2.60	1.80	**1.70**
Total of all items	10.25	6.57	2.93	**2.70**

NOTE.—Since test was completed the average time of turning drivers has been somewhat lowered, as shown in heavy black figures.

From W. R. McKeen's paper before Railway Master Mechanics Association, 1904.

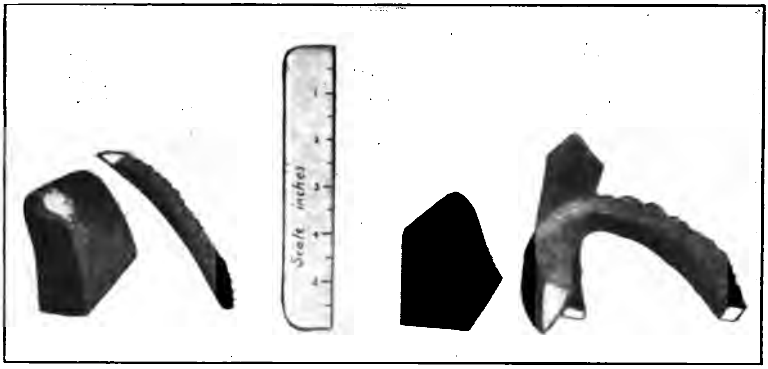


FIG. 29—TESTS NOS. 1 AND 2. ON LEFT, NOSE OF CARBON TOOL AND CHIPS REMOVED DURING FIVE SECONDS. NOTE BURNED CONDITION OF CUTTING EDGE AFTER 8-FOOT LONGITUDINAL CUT (TWO STROKES OF THE PLANER). ON RIGHT, NOSE OF ALLOY STEEL AND CHIPS REMOVED DURING FIVE SECONDS. EDGE PERFECT AFTER ROUGH PLANING TWO SIDE-ROD CHANNELS.

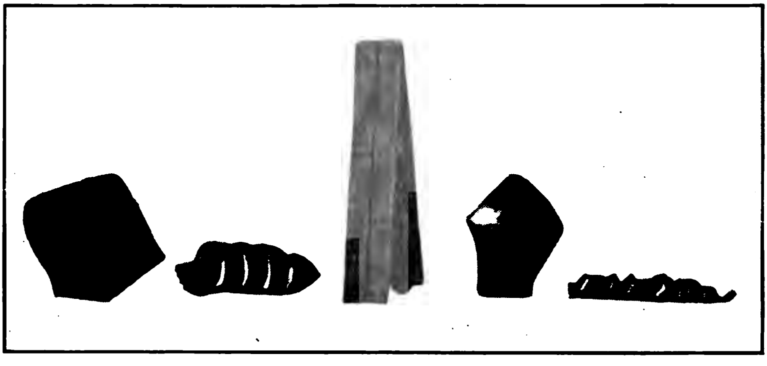


FIG. 30—TESTS 3 AND 4. PICTURE SHOWS EQUIVALENT TURNINGS BY THE TWO TOOLS; THAT IS, THE PROPORTIONATE AMOUNT TURNED BY EACH IN THE SAME LENGTH OF TIME. ON THE LEFT IS THE ALLOY TOOL WITH ITS CHIP AND ON THE RIGHT IS THE CARBON TOOL. BETWEEN THEM IS A SIX-INCH RULE.

From W. R. McKeen's paper before Railway Master Mechanics Association, 1904.

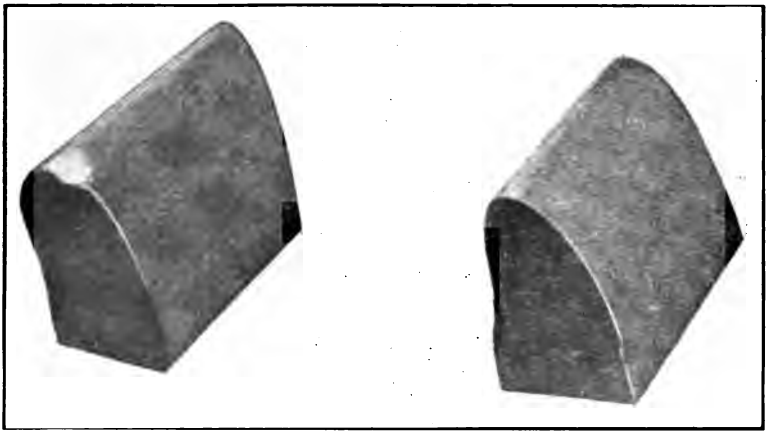
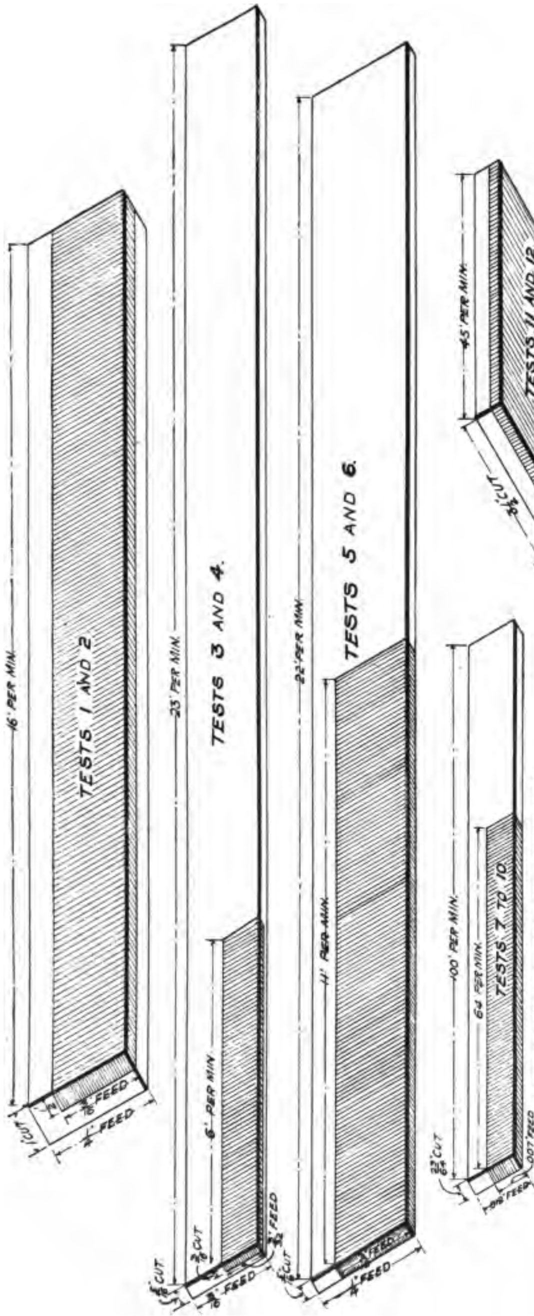


FIG. 31—TESTS 5 AND 6. TOOLS USED ON CAST IRON. ON THE RIGHT, ALLOY TOOL, AND ON THE LEFT, CARBON TOOL. NOTE BURNED CONDITION OF THE LATTER AT THE END OF A FEW MINUTES' USE.

FIG. 32—TESTS 7 TO 10. ON THE LEFT, ALLOY TWIST DRILLS USED IN THESE TESTS. PERFECT CONDITION UPON COMPLETION OF WORK. ON THE RIGHT, ORDINARY CARBON DRILL. EDGES BURNED AFTER DRILLING ½-INCH HOLE.

From W. R. McKeen's paper before Railway Master Mechanics Association, 1904.



COMPARISON OF MATERIAL REMOVED.

ACTUAL VOLUME REMOVED REPRESENTED IN OBLIQUE PROJECTION.

TESTS 1-6:- THE DEPTH OF CUT IS REPRESENTED ACTUAL SIZE, THE FEED TEN TIMES AND THE SPEED IN FEET PER MIN. ONE-TENTH ACTUAL SIZE.

TESTS 7-12:- THE DEPTH OF CUT IS REPRESENTED ACTUAL SIZE, THE FEED ONE HUNDRED TIMES AND THE SPEED IN FEET PER MIN. ONE ONE-HUNDRETH ACTUAL SIZE.

From W. R. McKeen's paper before Railway Master Mechanics Association, 1904.

COMPARATIVE PERFORMANCE OF ALLOY AND CARBON STEEL.

Machine and Equipment.	Metal Machined.		Feed per Revolution. (Inches.)	Depth of Cut. (Inches.)	Speed. (Ft. per min.)	Power to Run Machine. Light. Volt.	Light. Amp.	Light. H. P.	Under Load. Volt.	Under Load. Amp.	Under Load. H. P.	Effective Horse-power for Cutting. H.-P.	% of Total.	Metal Removed. (Pounds.) Per Hour.	Per H. P. Hour.	Tool. Size. Height-Width (Inches.)	Angle Top.	Angle Front.	Angle Side.	Kind of Steel.	Total Longitudinal Feed. (Inches.)	Time of Test. (Minutes.)	Condition of Tool after Test.	Remarks.
Planer, 60"x 60"x 30' 20 horse-power Westinghouse motor	Soft steel side rods 4' 8" long cut	1	¼	1	16	219	43 8	12 9	219 4	71 1	20 9	8	38	780	97 5	2¼ x 1½	60°	80°	80°	Alloy	4	4¾	Very good.	Limit of machine.
		2	3-16	¼	16	219	43 8	12 9	212	66	15.9	3	19	288	92	2¼ x 1½	60°	80°	80°	Carbon	¾	¾	Burnt ¼"	
Wheel lathe, 100" swing. 15 horse-power Westinghouse motor Gear driven.	Old and badly worn Standard driving wheel tires, 70" dia.	3	3-16	5-16	23	228	12	3 7	226	21 2	6 4	2 7	42	96	36	2¼ x 1½	82°	78°	88°	Alloy	4	17	Very good.	
		4	3-32	3-16	6	226	6	1 8	228	7 6	2 3	.5	22	13	30	2 x 1	82°	78°	88°	Carbon	½	27½	Burnt up.	
Pond engine lathe, 42". 20 horse-power Westinghouse motor Countershaft.	Hard cast iron Cylinder. Bushing, 28" dia.	5	¼	5-16	22	227	25	7 6	228	38	11 6	4	34	180	45	2 x 1	60°	80°	80°	Alloy	6	8	Good.	
		6	3-16	5-16	11	228	24.5	7 4	228	32 6	10	2 6	26	54	20 7	2 x 1	60°	80°	80°	Carbon	4	14	Burnt up.	
Vertical milling machine. 10 horse-power Westinghouse motor	Cast iron locomotive shoe.	7	00674	.....	45	222	6	1 8	222	15	4 4	2 6	59	193	73	4½" dia. x 3½" face	.		....	Alloy	20	6	Very good.	
		8	.00275	.....	45	222	6	1 8	219	10 7	3 1	1 3	42	82	63	4½" dia. x 3½" face	..		....	Carbon	20	14½	Burnt.	
Radial drill. 3 horse-power Vertical Westinghouse motor.	Medium hard cast iron blocks, 5" deep hole.	9	012	Mean 23-64	100	230	4 5	1 4	228 6	16 6	5 6	4 2	73	88	21	1 7-16" dia.			..	Alloy	6	1.50 sec.	Very good.	Limit of machine.
		10	007	Mean 23-64	64	230	4 5	1.2	228 3	8 5	2 6	1 4	34	51	36 4	1 7-16" dia.	.	...	...	Carbon	6	2.55 sec.	Burnt.	
Radial drill. 3 horse-power Vertical Westinghouse motor.	Soft steel cutter blanks, 4" deep hole.	11	.012	Mean 23-64	100	230	4 5	1 4	222 9	16 1	4 7	3 3	70	88	26 7	1 7-16" dia.	. .	.	. .	Alloy	6	6	Very good.	Limit of machine.
		12	.007	Mean 23-64	64	230	4	1.2	227	10.9	3 3	2 1	63	31	24.3	1 7-16" dia.	......	......	......	Carbon	2	14½	Burnt ¼"	

From W. R. McKeen's paper before Railway Master Mechanics Association, 1904.

FIG. 33—PHOTOGRAPH SHOWING THE LARGE CHIPS REMOVED BY HIGH-SPEED STEEL IN FLUTING MAIN RODS. IN THE TESTS 780 LBS. OF METAL WERE REMOVED PER HOUR WITH ALLOY STEEL AS AGAINST 288 LBS. WITH CARBON STEEL.

From W. R. McKeen's paper before Railway Master Mechanics Association, 1904.

PRACTICAL ADVICE TO COLLEGE MEN.

IN the past few years an entirely new profession has developed, known as commercial engineering, brought about by the keen competition of manufacturers. The engineer of today who is not able to take hold of a proposition and figure results from a business standpoint is likely to be left at the post. The Panama Canal is not being built as a triumphal exploit of engineering skill, but because it will cheapen the cost of ocean transportation; the Lucian cut-off on the Southern Pacific, with its thirteen miles of trestle-work over Great Salt Lake, although it represents the acme of achievement in railroad construction, was not built as a scientific experiment, but was brought about because by this method Oriental freight could be put from San Francisco into the Eastern markets at so much less per ton.

Economic Value of Commercial Engineering.

This is the great and, in fact, the only idea for any young man to keep in mind when leaving college and starting in for himself. The majority of men within my hearing today will, no doubt, on the completion of their college course, find their way into the employ of some manufacturing concern. The question will be, then (if the young man intends to make his mark), not how nicely can he sketch a plan on a piece of tracing-cloth, or how clearly can he elucidate upon the many theories of applied mechanics, but how much of a saving can he show in shop management? How much can he cheapen the production of some particular article? What can he do to help tone up the plant so that the best results can be obtained from his particular department? These are the problems he will have before him, and these only must be kept in mind if he expects to make a showing worthy of note, and of sufficient importance to attract the attention of the head of the concern.

Applied Education.

Among practical, everyday shop men the average technical graduate is given very little consideration. This, of course, may be the misfortune of the shop men or it may be the effect of the attitude of the graduate. The fact remains that there is a great deal of truth in the statement. In nine cases out of ten when a technical graduate secures a position in a shop of any kind he is considered of about as

much use as an ordinary helper, or he is classed under the rather ambiguous title of special apprentice, and duties are assigned him in about the same proportion. The graduates themselves, in my experience, are greatly responsible for this state of affairs. They enter a shop knowing almost to a certainty that this exists, yet in many instances they make no effort to change the general opinion. They take hold of the work that is given them in a rather perfunctory manner, and seem incapable, in many cases, of developing ideas on the subject at hand, and in a short time they find themselves moving in the same old rut of shop routine that may have existed ever since the shop was built. Instead of keeping their eyes open for chances for improvements and taking them up in the proper manner, they are content to allow things to drag along with as much unconcern as if they had never been blessed with advantages of any kind.

College Men in Machine Shops.

This is the point that I want to impress on your minds: Be on the lookout for improvements in methods of all kinds at all times. Don't think for a moment that I am decrying mechanical training simply because a great many of the graduates have been made seeming failures. The trained men are the men that are needed; the technical men are the men that have to fill the important places in all cases. They must be the pioneers!

The theories of today become the practices of tomorrow, and the men who can look ahead and anticipate a demand are the men that are going to win in the long run. Have a systematic line of investigation that you intend to carry out if ever you enter a shop, no matter what may be its kind of output. Keep the cost of production ever in your mind, and let no chance escape you if you see an opening of any kind for improvement.

If you enter a machine shop don't be content with doing whatever little detail you may be assigned to on some particular bench or machine. Note the entire layout of the plant. See what kind of power they are using. Note the method of transmission. Keep an eye on the class of machines in service; also their condition. Check up the speeds of shafting at the first opportunity. Note the method of making tools. Read up on tool steels. Keep in touch with the newest and latest catalogs on machinery. Compare the methods with other shops. Check the price lists of similar articles made in other parts of the country. In fact, familiarize yourself with every item of interest in any way connected with the article in

Practical Pointers.

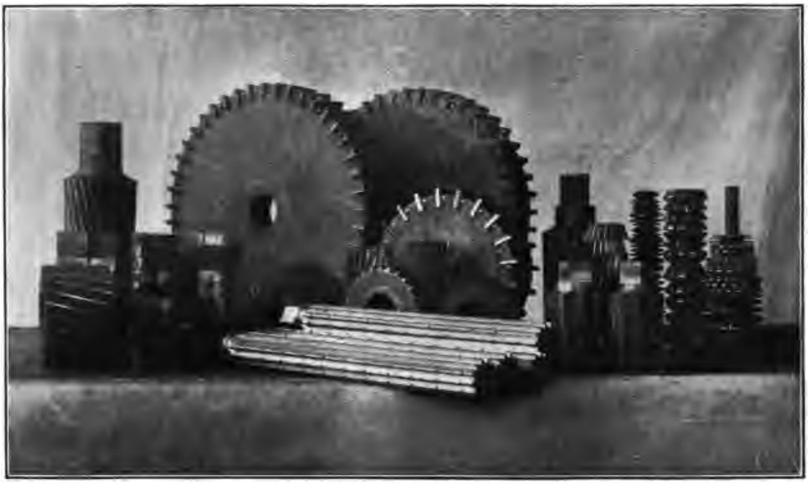


FIG. 34—MILLING CUTTERS, REAMERS AND HIGH-SPEED TOOLS, MANUFACTURED IN A RAILROAD SHOP TOOL-ROOM UNDER THE DIRECTION OF A MODERN TOOL-ROOM FOREMAN.

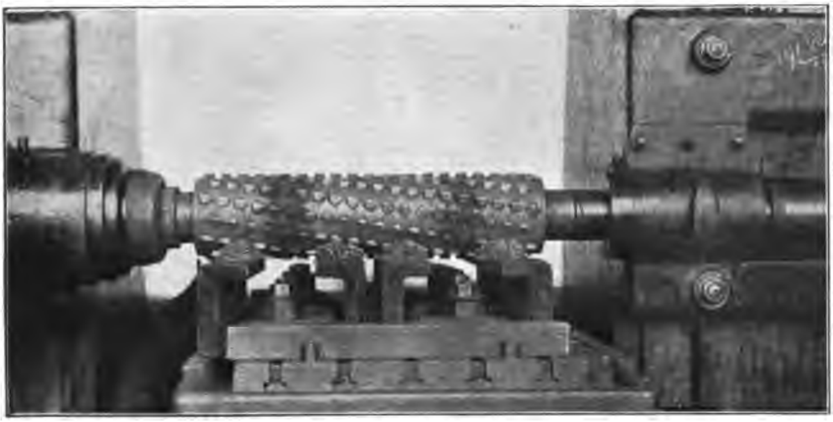


FIG. 35—LARGE MILLING CUTTER FINISHING FOUR ROWS OF DRIVING-BOX SHOES AT ONE TIME. SUGGESTION OF MACHINE SHOP FOREMAN.

FIG. 36—LARGE COMPOUND MILLING CUTTER FINISHING SEVEN SURFACES AT ONE TIME. SHOWING A FOREMAN WHO IS SPECIALLY INTERESTED IN IMPROVED DEVICES OF THIS KIND.

question. You will be surprised how soon you are noted by some official of the organization. I have had too many years of actual experience in shop work not to know that I am speaking the exact truth. If you are in the designing department, don't put in your time seeing how nice a set of lines you can embellish with graceful curves, but see how much machine work you can eliminate in the assembling-room. No one will deny that the sale of any article, no matter what it may be, is very greatly affected by its general appearance. It must look neat, as well as be reliable, but the days of elaborate finish are past.

There was a day when buildings were equipped with heavy trappings of all descriptions and locomotives were encircled with rings of polished brass, but the best sellers of all merchantable articles today are those of the plainest finish.

It is not how nice does a locomotive look today; it is how many tons can it haul. It is not what sort of a polish do you have on your line shaft; it is how many revolutions can it make a minute. It is not what style of architecture is your furnace built in; it is how many tons of pig iron can it turn out in twenty-four hours.

I believe, however, I have talked long enough on generalities, and I think, perhaps, I could demonstrate to you much more clearly with the following illustrations, than I could explain otherwise what I mean when I speak of "toning up" a plant.

After this introductory address about 150 lantern slides were shown, illustrative of these methods of "toning up" as applied to railway shop work. The first group of slides dealt with the general layout and of material storage and handling arrangements of a large shop.[1] The next group dealt with the methods of improving machine belting, this being one of the first points to be taken up when shop betterment is undertaken, as by this alone the efficiency of the machines will be increased as a whole from 10 to 30 per cent.[2] The third series showed the changes in shop methods, machine tools and devices, incident to the use of the new high-speed alloy tool steels developed since the introduction of the Taylor-White process. After these were shown some views of machine betterments necessitated by the intensive shop production due to the use of these high-speed heavy-service tools, such as the substitution of steel for cast-iron gears, the increase in size of driving and feed pulleys and gears, the strengthening of steady rests, housings, etc.[3] Then followed illustrations of a

Shop Betterment.

[1] For lay-outs of representative railway shops, see chapter 2, "Railway Shop Up to Date."
[2] See p. 120 for an efficient method of keeping belts up in shape.
[3] See pp. 39, 48, 125, 133, for illustrations and descriptions of typical machine betterments.

number of special devices for use in railway shops, showing how, by the exercise of a little ingenuity in the tool-room, the cost of machining many special locomotive parts could be greatly reduced.

Next after these were shown special jigs for use on the machines, and then followed a long series of slides on the subject of tool standardization for an entire railway system; *i. e.*, standardizing punches, drills, reamers for crosshead, knuckle pin, and ball joint work, flue rollers, etc. A number of views were then given of a recent very light air motor that has many advantages for work in close quarters, and on account of its efficiency. Following these, various devices for use in erecting floor work were shown, cylinder-boring machines, valve-facing device, a convenient portable air hoist for main air reservoirs on engines, guide lining device, valve bushing extractor, etc.

Mr. Jacobs concluded his address with a very interesting description of the individual effort system for rewarding labor as applied in a large shop to effect economical production and to reduce to a satisfactory basis the wage problem.—*An abstract of an address by* H. W. JACOBS *before the engineering students of the University of Kansas, as published by the American Engineer and Railroad Journal, April, 1906.*

PRACTICAL ADVICE TO COLLEGE MEN.

EDITORIAL COMMENT BY AMERICAN ENGINEER AND RAILROAD JOURNAL, APRIL, 1906.

Mr. Jacobs's address to college students, which is partially reproduced on another page, should be read by all those who are interested in the matter of shop production. It is not surprising that the engineering colleges have neglected to impress the students with the importance of the cost of production. It is only during the past few years that the manufacturing concerns have waked up to the importance of this problem, and apparently some of the railroad shop managements are still blissfully unaware of it. The successful shop manager is one who realizes the importance of studying the cost of production with a view to reducing it and increasing the shop output.

ORGANIZATION AND EFFICIENCY IN THE RAILWAY MACHINE SHOP.

(ADVANCE ANNOUNCEMENT IN THE ENGINEERING MAGAZINE.)

Because the railway shop is not competitive—because it does not have to study expenses closely so as to undersell a rival manufacturing a similar product—because it did not have to measure its costs against energetic and alert business rivals—it has been slow to adopt the methods of shop betterment and works organization which have been almost universally adopted into manufacturing concerns.

Lately, however, the close scrutiny of operating expenses has roused the mechanical departments of our railways to a keen and most active study of the best ideas and methods adaptable to the railway machine shop, and there has been a great awakening, and some of the large American transcontinental roads have gone as far perhaps as any commercial establishment in studying to bring their work down to a minimum cost per unit. The new movement is full of interest and importance, and not only to the man in charge of motive power and equipment, or of the shops themselves or any department of them, but also to the manufacturer of modern tools and materials. It has opened new opportunities for men and machinery already in many of the larger railroads, and it will inevitably extend rapidly to all, large and small.

Mr. Jacobs is one of the leaders in this movement, and has made the greatest success in carrying out this work. He is engaged in it now, and the methods he describes have been tried out in the shops of one of the greatest transcontinental lines. Everything he suggests is practical—the result of thorough trial and perfection under working conditions. He does not speculate as to what might be done, but tells what has been done, how it was done, and what profits resulted. And the pictures bring the actual work of the shop, and the practical improvements, directly before the eye of the reader; they tell a story as valuable as that of the text.—THE EDITORS.

CONTENTS.

ORGANIZATION AND EFFICIENCY IN THE RAILWAY MACHINE SHOP.

I. SPECIALIZING AND CENTRALIZING THE OPERATION AND EQUIPMENT.

RAILROADS in the United States perform the functions of common carriers and of money-makers. As carriers, besides their relation to the land and the people, they must be adapted to the trade of their territory and connections—in facilities, capacity, and operative efficiency. As the property of private persons, they must be managed and operated to effect the greatest ratio of net earnings to investment, besides conforming to the compulsions of the law, and to their own interests in commerce. Men trained as engineers in both the schools of induction and of practice, are as a class best able to bring about these results, as their work is constructively directed toward the end in view after intelligent analysis of actual conditions. We shall deal with some concrete problems of the engineer in relation to the maintenance of operative efficiency of the motive power and rolling equipment—those most active factors of earning power and expense in existing steam roads.

Function of Railways.

To move the traffic of a road, locomotives and cars are required. These must be built, maintained in running order, repaired, replaced, and must be designed with reference to safety, efficiency and operative economy, cost, adaptability, durability, simplicity and interchangeability of parts, and facility of repairs.

Whether a road builds its own equipment or not, it has a large voice in specifying design, and it must keep up the running condition; these functions require both the mechanical and the industrial engineer.

Great manufactures, such as the steel industry, have been successful on a large scale. The methods under which they thrived are applicable wherever there are manufacturing shops. Railroads have been slow to modernize their shop methods and to refine their mechanical practice, because the chief spur is to earn dividends by means of transportation. They are only very indirectly affected by the forces governing competitive and economical manufacture in commercial enterprises, and less indirectly by the forces making for greater serviceability of equipment. But if the experience of the commercial manufactories is profited

Commercial Manufacturing Methods.

by, and modern methods adopted wholesale, modified to suit such conditions as may be peculiar to railroads; if the improved products, developed at such cost in the commercial world, are but taken as they are found, and used effectively, great improvements in operative and maintenance efficiencies and economies will ensue, resulting in the two-fold gain of lowered running cost and fixed charges, together with capacity for handling larger business, with greater gross, and redoubled net earnings.

All this is not mere argument, but is demonstrated by actual instances, late and near at hand. The managements of the roads are waking up to these capabilities and rapidly availing themselves of them. Cast steel and malleable iron are substituted for cast and wrought iron, wherever they may with advantage be used. Patterns were re-designed, re-classified and standardized, many being obsoleted, surplus of material being done away with both on account of the needless higher first cost of the casting, and the increased time of machining; bolt holes are cored so as not to require drilling, and design is strengthened to take care of weaknesses shown by exhaustive records of all classes of breakage to parts of motive power and rolling equipment; locomotive and car elements are standardized as far as practicable, and new equipment is ordered to conform to these specifications. The Harriman lines and the Rock Island have been conspicuous examples of such standardization, broadly conceived and comprehensively carried out.

Improved Equipment and Shop Practice.

Tests are becoming more thorough and less perfunctory, and as a result, design is continually changing for the better. Not only is there thus a general tendency toward improvement in quality and efficiency of equipment, but there is also a growing determination to provide the very best shop facilities for taking care of repair and replacement, as at the Moline (Rock Island), Topeka (Santa Fe), Collinwood (Lake Shore) Omaha (Union Pacific), and other large recent shops. And in these shops, centralized, large, there is a growing effort toward intelligent systematization of manufacture, toward rapid production at low cost, and toward using men and machines to full economical capacity.

The direction in which railroads are slowly moving is the right one; this paper advocates some of the means by which these results can be attained in a still larger way.

In the first place, salaries and wages are too low. I am no advocate of increased pay-rolls; but it is shown in practice that five men worth

FIG. 37—A BRAKE-SHOE KEY FORGING DEVICE DESIGNED BY A BLACKSMITH SHOP FOREMAN. IT FORGES TWO KEYS AT ONE TIME FROM SCRAP IRON, TURNING THEM OUT BY THE THOUSANDS AT VERY LITTLE COST, WHERE FORMERLY THEY WERE MADE LABORIOUSLY BY HAND. WITH THE ENORMOUS NUMBER OF KEYS USED ON A RAILROAD HANDLING A LARGE FREIGHT BUSINESS, AN ITEM OF THIS KIND IS WELL WORTH CONSIDERING.

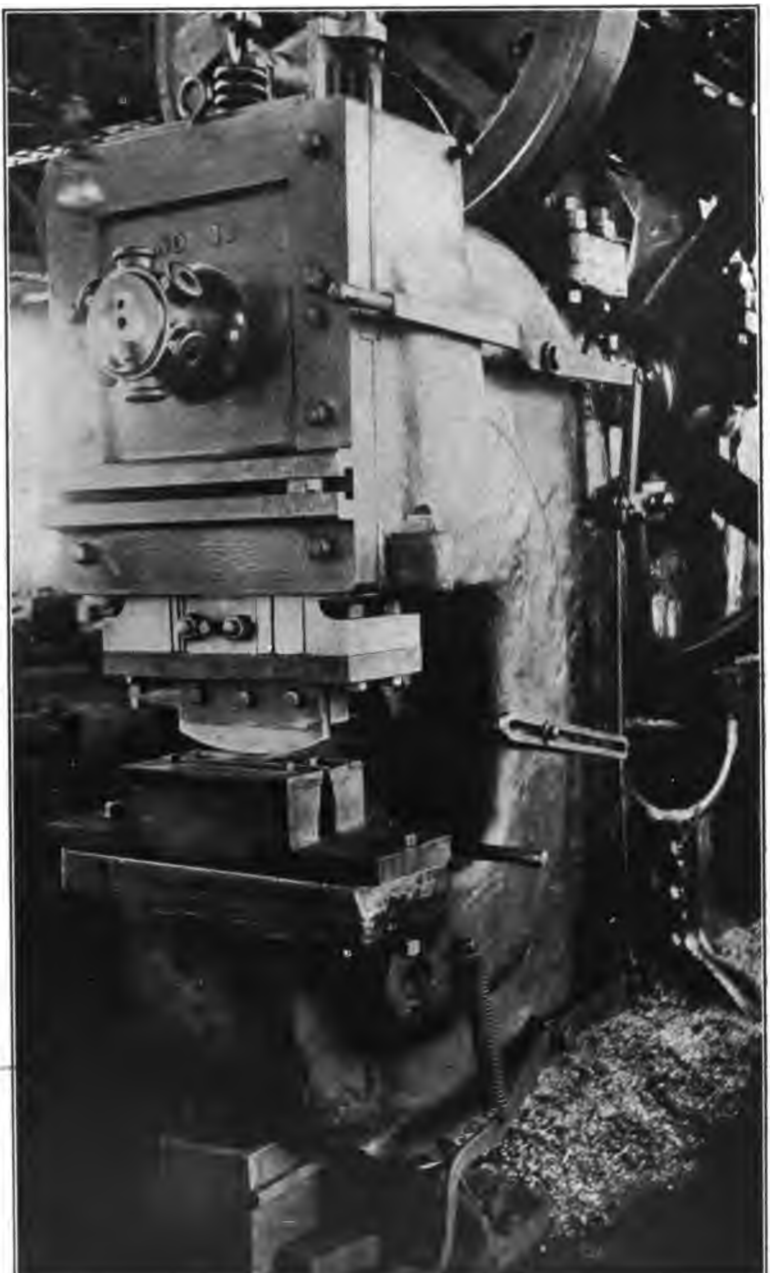


FIG. 38—SHEAR WHICH TRIMS AND BENDS SHOE KEYS IN ONE OPERATION. THE KEYS ARE FORGED IN THE MACHINE SHOWN ON THE PRECEDING PAGE. DESIGNED BY BLACKSMITH FOREMAN.

$4 a day each can do as much as ten $3 men, and the same is true of a foreman earning $80 or $90 compared to one earning $150 to $200; or of an official belonging to the $200 class compared to one belonging to the $600 class. The high-priced man is not necessarily the best; but for the high price the best can be secured. It is manifestly false economy to pay a master mechanic $175 a month, and give him charge over one thousand or two thousand men with an aggregate pay-roll of $60,000 to $100,000, when an intelligent $300 man, bringing perhaps in his train a $500 staff of assistants and specialists, can in six months lop off 15 to 30 per cent of this pay-roll, and at the same time by system and specialization and a method of reward according to merit, give increased and better service.

Salaries and Results.

Similarly, a $90 foreman is not an economical man to whom to entrust the requisitioning of thousands of dollars' worth of material each month; he will generally order perfunctorily and far beyond his needs, and it is not usual for his requisitions to be effectively checked up. There is, for example, the case of a road that had but two engines of one particular class, under experiment, which they would transfer from one division to another to get figures on their service. After they had been in use about two years and had been overhauled in three different places, the president called for an itemized expense statement; and when the supplies were checked up at the different stores there were found to be fourteen sets of grates, nine sets of cylinder-heads, four sets of pistons, two complete sets of rods, besides numerous cylinder-head casings, valve packings, piston rings, etc.,—more stock, in fact, than these two engines would use in ten years of hard service. This is perhaps an unusual case, but it is actual, and no one was to blame but the system. Each foreman at the different points thought it was his duty to keep up the supplies, and in a sense he was right, as no one wished to score a failure while the engines were in his particular territory. But if the foreman had been a man of good judgment, he would have consulted the storekeepers and others before ordering indiscriminately, and if there had been higher officials who would not have let such a condition come into effect, but would have permitted the ordering only of what was necessary, and would have intelligently transferred the material on hand as became requisite, all this needless investment in new material would have been obviated. Multiply this cost by the number of engines on a road, and perhaps cut the total in two on account

Example Showing Expense of Cheap Supervision.

of its being an exceptional case, and the prevalent condition on many a road today will be pictured. Plainly, almost no salary is too high if it will secure the prevention and correction of this sort of practice.

Value of Foremen With Ideas.

There is now and then in a railroad shop a foreman whose ideas are of a special merit, which, if encouraged, can be of thousands of dollars benefit to a company.[1] Such is the case of the blacksmith foreman who designed the brakeshoe-key forging machine here illustrated. This machine was reconstructed from an old bulldozer, and forges two brake-shoe keys at a time from scrap car bolts. Whereas these keys used to be made laboriously by hand, they are now turned out by the thousand at very little cost. With the enormous number of brakeshoe keys used on a railroad handling an immense freight business, an item of this kind is well worth considerable attention.

Centralized Manufacture of Parts.

Centralization, as applied to shop work in the railway world, is not exactly a new idea, although the subject has been more or less agitated by manufacturing concerns for years, and to this is largely due the success of some of our great modern trusts. But the development of this policy in railway lines is quite recent. The stride it has made in the immediate past, and which it is at present making among the railways of the United States, is worthy not only of comment, but of the serious consideration of every railway official who believes in "Economy and Efficient Service."

There are many things to be considered when taking up a proposition of this kind, involving serious and complicated problems which must be decided upon before a successful working basis can be established. First of all, should be considered the location of the railway in question, its mileage, and general layout, and particularly the location of the division points and headquarters, shops, etc., with reference to the original base of supplies.

It would not pay, for instance, for a straight overland line, say of 1,500 or 2,000 miles in length, with good facilities, foundries, etc., at each end of the line, to decide to manufacture all of the material at some point near the middle of the line, where no foundry or other needed equipment was located. I have in mind a certain railway, whose machine shop was located near its western terminal; its largest car shop was a little farther east, and it bought its wheels from a foundry at its extreme eastern terminal. With the idea of centralization of work in mind, the people in charge ordered all wheels for car work

[1] See pp. 31, 85, 102 for other improvements and devices suggested by foremen.

FIG. 39—THE PRODUCT OF A FEW DAYS' WORK ON THE BRAKE-SHOE FORGING AND TRIMMING MACHINES.

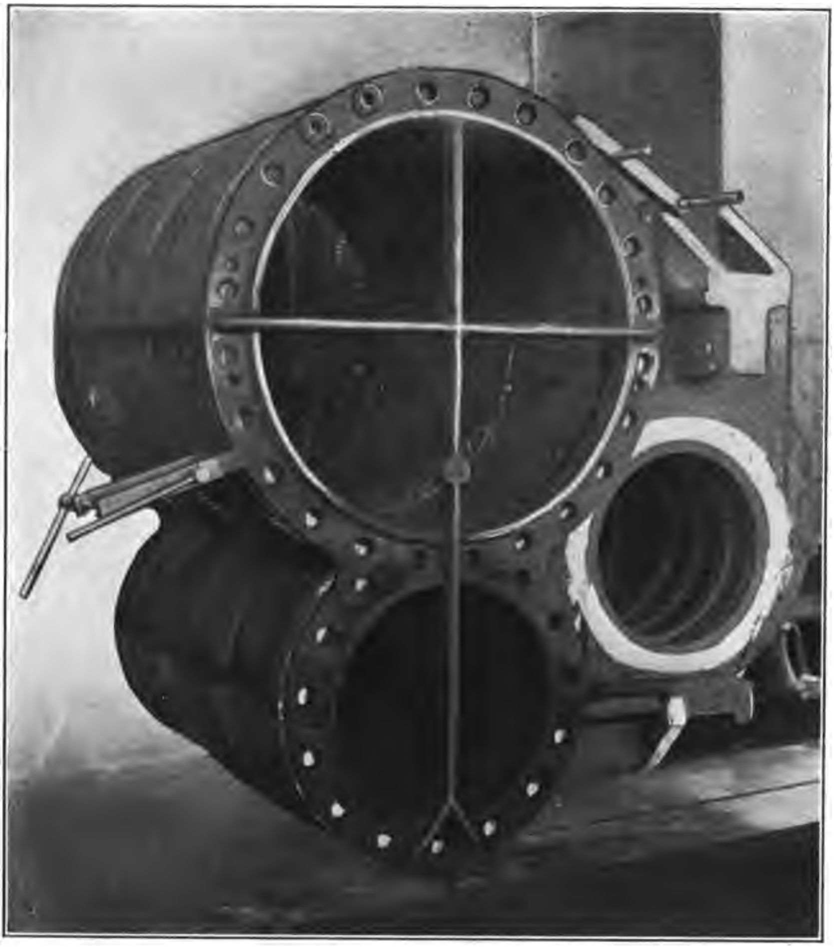


FIG. 40—TEMPLATE USED IN DRILLING COMPOUND CYLINDERS FOR CYLINDER HEAD STUDS. THIS SAVES HOURS OF WORK IN LAYING OFF THESE HOLES BY HAND AND INSURES ABSOLUTE ACCURACY AND INTERCHANGEABILITY.

fitted up at the western end. This caused all new wheels to be hauled back after being mounted. It also caused all old wheels to be sent west to be stripped, and then hauled back the entire length of the line as scrap. This haul in freight alone, at one-half cent per ton mile, cost $1,200 in a month, besides causing an extra delay of at least one day in delivery from the time the wheels left the foundry until the time when they were mounted and ready for the cars. Of course, the argument can be made that centralization was not at fault, but rather the location of the shop with reference to the base of supply. This is indeed true, and all this trouble could be avoided by relocating the shop. But this discussion is not intended to include the provision of new equipment; it is intended to confine the consideration to plans which will work with the present equipment of the road in question. There is not one railway in twenty now in a position to consider the rebuilding of all its shops, or even the relocation of its base of supply. We must deal with conditions as we find them.

Unfavorable Conditions for Central Manufacture.

A shop that turns out finished material, whether it be pilots or petticoats, is a manufacturing concern or establishment, and must be recognized as such. It requires no large array of figures to prove that the larger the output of a given article, the lower will be the labor cost per piece. If a man can turn out six brasses, for example, in one lot at a given rate, it stands to reason that he ought to turn out twenty at one time at a reduced rate per brass. This is true of any other article needed in railway work. The fewer the changes of tools and settings to make, the less the number of tools to keep up; and the more familiar the workman becomes with each particular class of work, the larger are the opportunities for the reduction of cost. Centralization of work allows for the full development of the specialist, which is the greater factor in the labor end of production. With one main shop and a foundry in connection with it, the furnishing of material ready for service for all points comes in line as naturally as a wrapping department in a large mercantile house. There is an even and logical sequence of operations in the movement of an article from the foundry or furnace to its place of service. This method reduces the amount of stock to be carried, and consequently does away with all the expense of extra handling of stock, etc. It reduces the amount of tools, jigs, and machines required to get the stuff in shape for service. For instance, it requires a certain expensive machine, a set of jigs, angle plates, tool-

Economy of Centralized Manufacture.

holders, etc., to prepare properly shoes and wedges, or driving boxes, for use on an engine.[1] If there are eighteen shops on the road where these are to be used, this calls for eighteen sets of tools, jigs, etc., for this particular article. With this job specialized and all done at one place, the chances are that one set of these tools, jigs, etc., would be sufficient to supply the entire equipment. Clearly, this would cut out seventeen no-longer-needed machines, sets of tools, angle plates, jigs, etc., besides the work and the man formerly required at each place, to fit up and keep them in good order. On one road where this was done it has secured a reduction in the small item of maintenance of machinery and tools, of $180,000 per year.

The Use of Jigs and Templates.

This particular template here illustrated saves hours of work in laying cylinders off for the stud and bolt holes and insures absolute accuracy and interchangeability, and if the cylinders are completely finished before sending out to a smaller shop, but the one template is required.

A jig or tool in continuous action is a money-saver, and there cannot be too many under these conditions. A jig or tool of any kind, lying idle, is so much "dead capital" or money lost. Take the basis of eighteen shops and eliminate seventeen sets of tools, plates, etc., for each special part of a car or locomotive, and the figures run away up into the thousands.

The illustration of knuckle-pin-hole reamers shows a case of a money-making tool. At the top of the pile (page 79) will be noted standard gauges. These are supplied to each shop and large roundhouse and a set of kunckle-pin reamers for the classes of engines dependent there. An engine comes in with a knuckle pin to be replaced; the hole is worn oblong; there are four of each nominal size of these reamers, varying from actual size to one-eighth inch above, by thirty-seconds. The hole is bored out by the smallest reamer possible, and standard taper knuckle pins, completely finished and kept in stock, supplied from the general shop where centralized manufacturing is carried on, are applied. This process results in great economy of time in a roundhouse. The reamers are tried, frequently, by gauge, and when worn small are shipped in to the central tool-room for re-grinding and re-setting of the cutting edges.

Standard Knuckle-Pin Reamers.

The solution lies largely in the hands of the supply department, more there than in any other. The hearty coöperation of the mechanical

[1] See p. 13 for description of special milling device for finishing eccentric halves.

FIG. 41—SET OF STANDARD KNUCKLE-PIN HOLE REAMERS, MANUFACTURED TO WITHIN .003 OF SIZE IN A CENTRALIZED TOOL-ROOM. AT THE TOP OF THIS PILE OF REAMERS WILL BE NOTED STANDARD GAUGES. THESE ARE SUPPLIED TO EACH SHOP AND LARGE ROUND-HOUSES, AND A SET OF KNUCKLE-PIN REAMERS FOR THE PARTICULAR CLASSES OF LOCOMOTIVES IN SERVICE. WHEN WORN, THE REAMERS ARE SHIPPED BACK TO THE CENTRAL TOOL-ROOM FOR REGRINDING AND SETTING.

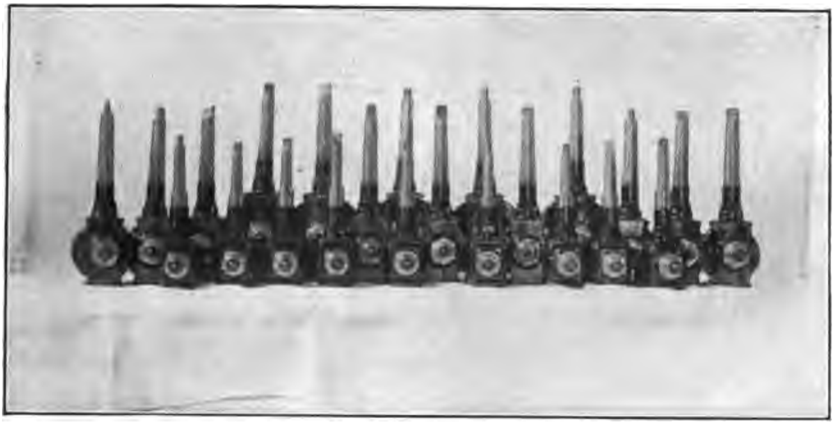


FIG. 42—GROUP OF ANGLE DEVICES FOR DRILLING WITH AIR MOTORS IN CLOSE QUARTERS, MADE IN CENTRAL TOOL-ROOM.

department is an absolute necessity, but the supply or store department should be the prime mover. It is the store department that should furnish accurate figures, annually, monthly, or on some periodical basis of consumption, as it is through this method only that the stock can be kept alive at all times. "Live" stock and its proper care, is fundamental to the entire railway-supply business.[1]

The store should have absolute figures on engines and cars, according to class and location, with a full set of pattern books and forgings, planing-mill lists, etc., right up to date, at all times. Records of tire wear, journal wear, fire-box conditions, mill records, changes in design, new modern styles, etc., should always be easy of access to the supply department. Records of the distribution of power, changes in location, new rules on switching and terminal work of all kinds, should always be given to the store department. Stated reports, preferably quarterly, should be furnished by all master mechanics, showing just what engines or coaches will be shopped in the following sixty days, and then, with the tire-wear figures, journal-wear figures, etc., it is easy to decide on material needed. A close check should be kept by the store people on all engines and cars, according to the classes and length of time at certain locations. The consumption of cylinders, castings, timber, etc., at these given points in a given time, say two years, would give figures that would be accurate enough to work by. With all this work up and a monthly check of all engines, according to class, that are repaired at each point, it should be no trouble to keep plenty of material on hand, and still keep the stock at an extremely low figure.

Storehouse Records and Reports.

On ten engines of Class I type, for example, located at five points, showing a monthly consumption of two link-lifter bushings, it would be a simple matter to cut up twenty feet of tubing and send six bushings, or three months supply, to each point. If this is not done, the chances are that each shop will order a 10- or 16-foot length, and thus have over 100 feet tied up, whereas one-fifth of the stock would have done the business. This example could be carried out indefinitely, until it numbered up in the hundreds, for every point on the system and for each class of engine. Thus the store, by an accurate and careful system of record-keeping, should have correct figures on consumption, and then put it up to the shop people to meet the demands. Let both departments get together and work hand-in-hand. Let the shop know what is expected, supply it with

Methods for Keeping Down Stock.

[1] The relation between the mechanical and store departments, p. 171.

material, and require it to deliver the goods. Let the shop people devise the ways and means and promulgate the methods; if the store supplies the figures and material, they are doing their duty; it is then up to the shop people; where the stuff can be put up the cheapest, there is where it should be done. If pilots can be made at one place cheaper than anywhere else, let that point make the pilots; if piston rods can be got cheaper at the same place, let that point make all the piston rods for the system, and so on through the list. After the cheapest point has been settled upon for each article, should it be found to pay to transfer certain machinery to another point, do not hesitate to transfer it. Logs used to be hauled to the saw-mills; now the saw-mills are taken to the timber. Men are like machines—if it would pay to transfer them, do not hesitate to do it. Do not keep an 18-K man in a 2-K shop; if you cannot give him an 18-K shop, take him to it. Give the best men the best facilities and the result will justify the move in every case.

If you get accurate figures, and have the stock properly handled, use the best methods and labor in each department, and have each department in the hands of a good man, and let his word be a law unto all—then the centralization of work cannot fail to be a true time-winner.

II. THE GENERAL ASPECTS OF STANDARDIZATION.

In one of the leading American railroad journals there appeared within the past year a series of articles dealing with the standardization of locomotives and of locomotive parts, for three railroad systems: the Rock Island, the Harriman lines, and the Canadian Pacific. The method of standardization has been so ably outlined and detailed in these articles that I shall not attempt in this place anything more than a description of the relation between such standard engines and engine parts and the shops.

Standardization of Locomotive and Parts.

The general standardization for the Rock Island was the result of recommendations of a "Committee on Power," appointed by direction of the president. This committee recommended as to the types of locomotives that should be adhered to in ordering future power, and as to the retirement and order of retirement of the older and inefficient classes of engines. A valuable and instructive system of determining depreciation of engines was devised by this committee. The standard types of engines decided

Rock Island Standards.

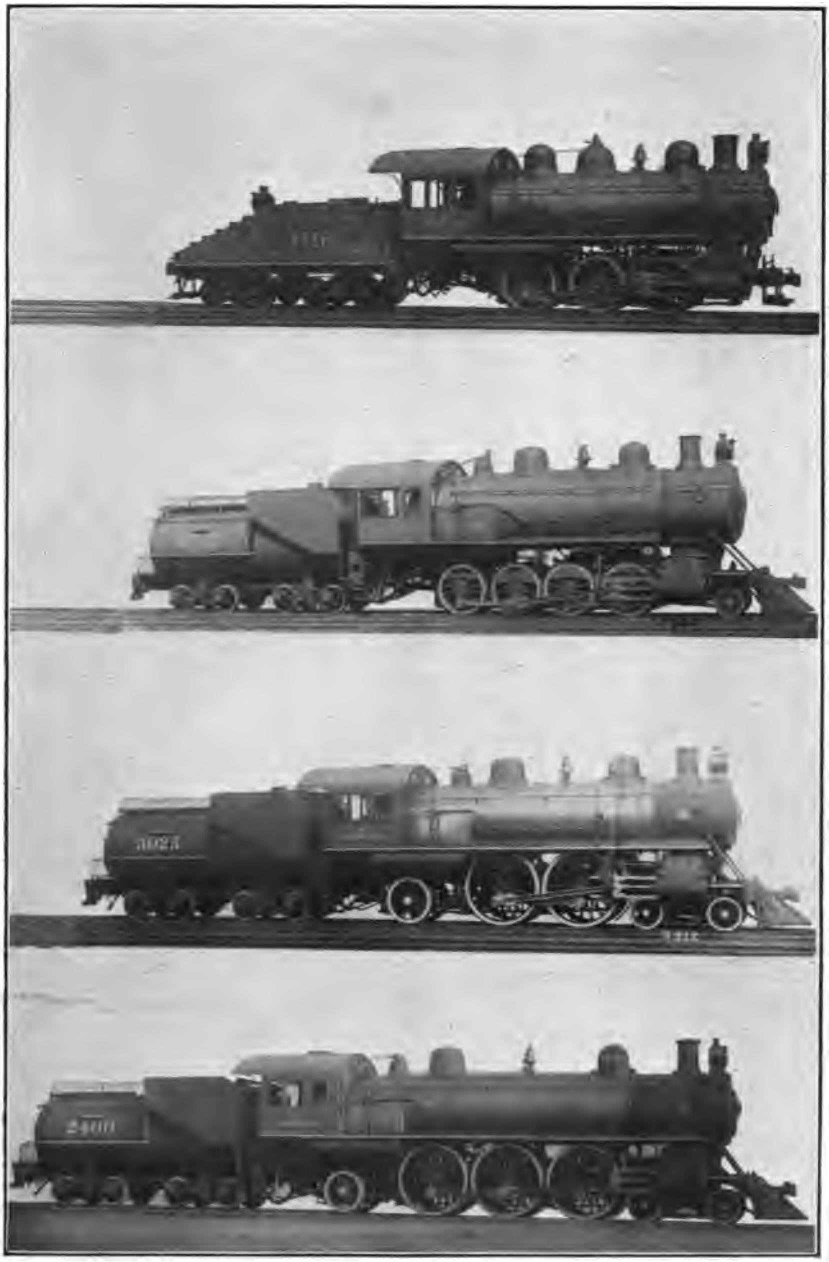


FIG. 43—PHOTOGRAPHS SHOWING THE FOUR TYPES OF COMMON STANDARD LOCOMOTIVES ON THE HARRIMAN LINES.

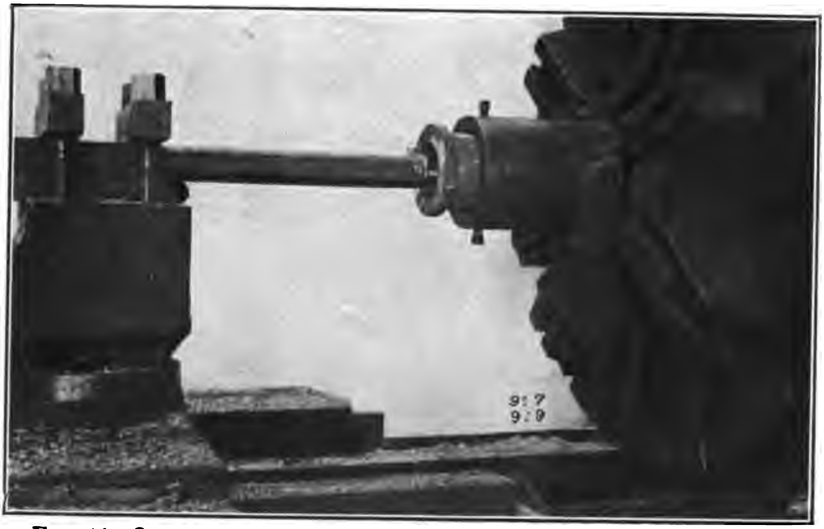


FIG. 44—OLD TYPE OF BORING TOOL FORMERLY USED IN BORING EXTENDED PISTON-ROD BUSHINGS.

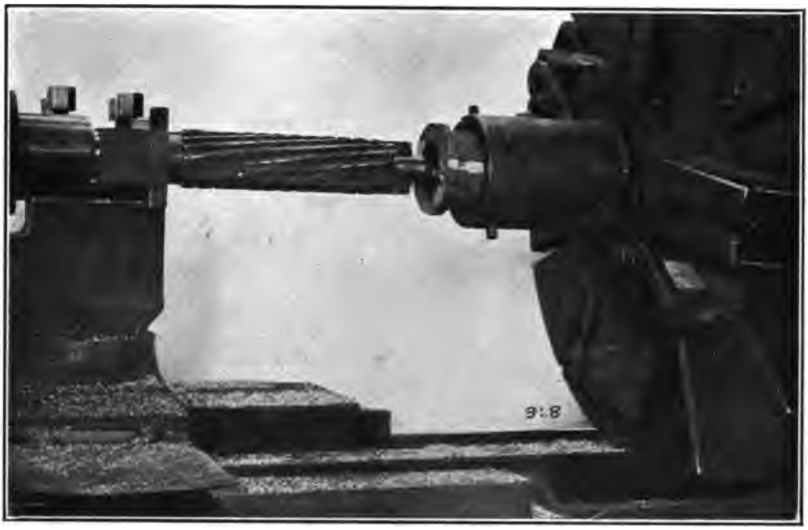


FIG. 45—BORING TOOL AND REAMER FOR FINISHING EXTENDED PISTON-ROD BUSHINGS. THIS TOOL SUPPLANTED THE OLD BORING TOOL USED FOR THIS PURPOSE, DOING THE WORK MORE ACCURATELY AND CHEAPLY. DESIGN OF SPECIAL APPRENTICE.

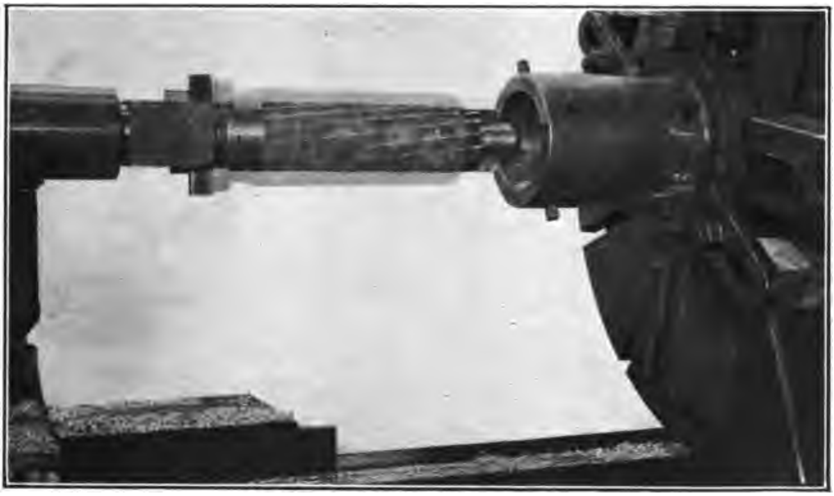


FIG. 46—VIEW OF EXTENDING PISTON-ROD BUSHING SHOWN IN "PHANTOM" ON REAMER AFTER THE BORE HAS BEEN FINISHED.

FIG. 47—HIGH-SPEED STEEL FLUE-SHEET CUTTER MOUNTED ON ARBOR READY FOR USE. CUTTER WEIGHS LESS THAN 1½ LBS., AND HAS A CAPACITY OF 100 HOLES PER HOUR.

upon were, broadly given, two types, being subdivided. For passenger service, the Atlantic, Pacific, and ten-wheel types were selected. For freight, the same ten-wheel type with smaller drivers, and a light and heavy consolidation. For switching, the six-wheel type.

Union Pacific Standards.

On the Union Pacific, under the director of maintenance and operation, a similar standardization was inaugurated. The types selected were in this case four, being the same as on the Rock Island with the elimination of the light consolidation and ten-wheel types.

Canadian Pacific Standards.

On the Canadian Pacific the standardization covers broadly but three types: the consolidation, the ten-wheel, and the Pacific. On the latter road the policy was adopted of making standard the parts for all new engines, as with the other two roads, and some of these parts standard for some classes of the older equipment, or standard with slight modifications.

Parts to be Standardized.

Motive-power officers, and their immediate superiors, having determined in a large way the types of power, can with profit proceed to a consideration of parts standardized. Of course, when standard specifications are drawn up for the detail construction down to the rivet holes and the kind of cab fittings of a class of engines ordered from a locomotive works, it may be said that the entire locomotive is standard; all the parts should in theory be interchangeable between locomotives of this class or type; moreover, some parts will be thus interchangeable for several or all types. Such parts are detailed in accompanying list number one.

Standard Part List No. 1.

Truck wheels and axle; trailer wheels and axle; trailer trucks; tender trucks, wheels and axle; driving axles.

Frame spacing and cross sections; methods of frame jointing; tender frames; deck beams; frame ties; expansion bearings.

Shoes and wedges, and wedge bolts; driving boxes, collars, and brasses; pedestals; truck boxes.

Steam pressure; boiler-seam design; fire-boxes and details; water space; flue diameter, thickness, and flue spacing (see opposite page); crown bars; fire doors; stay bolts; mud rings; grates; washout plugs.

Front-end diameter; front-end rings and doors; exhaust nozzle; petticoat pipe; diaphragm plate and netting; exhaust and steam pipe seats; smoke stack diameter; T heads.

Pilots; front beams; pilot braces; bullnose and pilot coupler.

Bells; sand boxes; domes; headlights; safety valves; whistle.

Cabs; cab accessories; all cab fittings; cab ventilator; throttle.

Air-pumps bracket; air reservoir.

Piston valves and valve rods, together with bushings; valve setting.

Main and side-rod details; wrist pins; knuckle and crank pins and bushings, except main crank pin; piston rod diameter.

Link motion complete, except radius of link; rocker arms and boxes; shafts and rods; reverse levers; eccentrics and eccentric straps.
Equalizer beams; hangers, fulcrums.
Brake beams; brake shoes.
Grab irons; steps.
Cylinder cocks; relief valve.
Lagging.
Oil cup and lubricator.
Most frame and cylinder bolts and studs; split keys and nuts.
Tank accessories; tank-valve hose and strainer.

With a very few exceptions this list of parts can be standardized for all classes of engines; besides these there are many other features that can be standardized in part, a few examples being:

Brake rigging.
Spring rigging and springs (leaf and coil).
Flue lengths.
Pistons and packing rings, etc.
Piston-rod lengths.

To indicate how certain construction or design determined upon as standard may affect the shop tools and methods, and how the cost of repairs with these standard parts is in turn affected by the methods used, I will cite a typical instance.

On one road it was decided to use extended piston rods on Vauclain compound engines, to counteract to some extent the rocking motion of the crosshead due to unequal pressure in the cylinders.

Substitution of Reamer for Boring Tool.

The portion of the piston rods which extended out of the front head of the cylinder passed through a long bronze bushing. It was necessary in equipping engines with these extended rods, as they passed through the shop, that the bushings should be bored out to an exact standard size. The ordinary boring-bar here illustrated, as used in a lathe, was not able to give sufficiently accurate results, and moreover was very slow and wasteful of time.

To overcome this difficulty and to get an accurate bore on these bushings while increasing the speed of the work, the reamer shown below was designed. This reamer is composed of an arbor, in which is inserted a flat cutter of high-grade steel. Behind the cutter, and $\frac{1}{64}$ inch larger than the cutter, is a straight spiral reamer of high-grade tool steel.

By means of this cutter and reamer the work could be revolved at much higher speed and the reamer fed in with a heavy feed, the spiral portion insuring an absolutely true bore. The saving in time of this production amounted to something over twenty minutes on each bushing, not counting the previous necessity of throwing out a large percentage of the bushings that were inaccurately bored. This time,

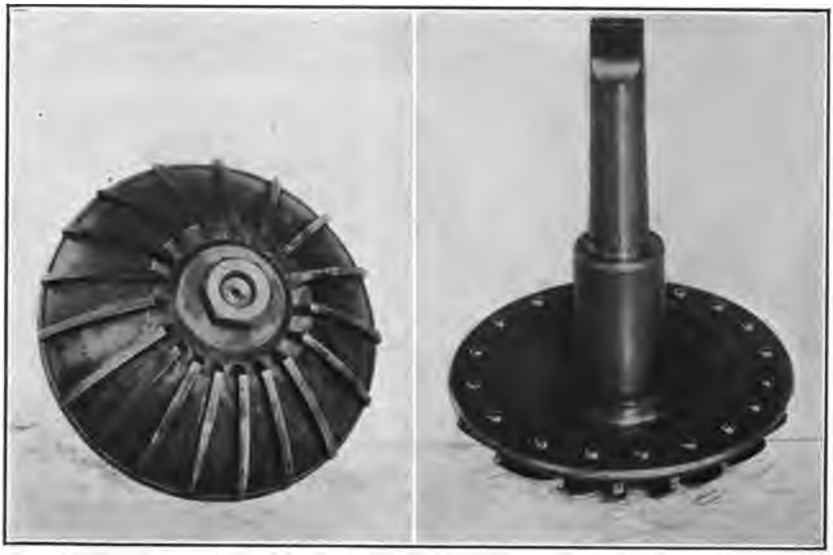


FIG. 48—BALL-JOINT REAMER FOR FACING STEAM AND DRY-PIPE JOINTS TO STANDARD RADIUS. THE BLADES ARE GROUND TO STANDARD SHAPE AND INSERTED IN THE BODY OF THE REAMER, AND IT WILL BE NOTED THAT THEY ARE OPPOSITELY PLACED THOUGH UNEQUALLY SPACED TO AVOID CHATTERING OF THE REAMER.

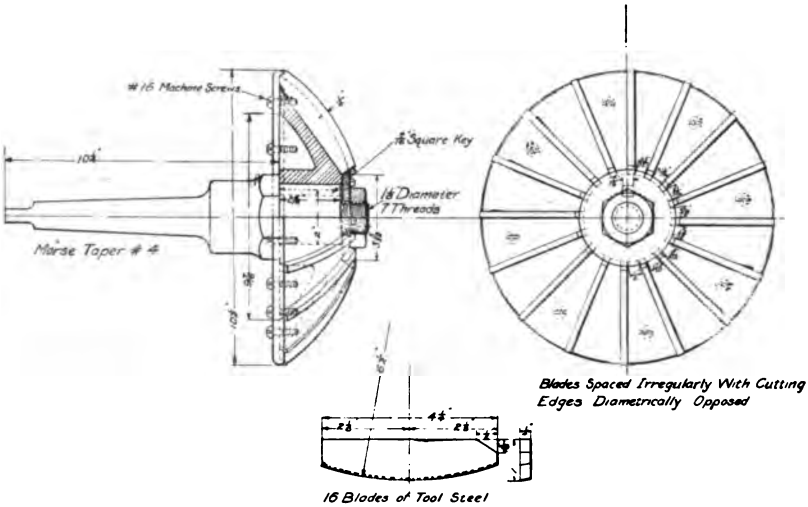


FIG. 49—ELEVATION AND SECTION OF BALL-JOINT REAMER, SHOWING THE DETAIL OF CONSTRUCTION. THIS REAMER FINISHES ALL STEAM AND DRY-PIPE JOINTS TO STANDARD RADIUS WITHOUT CHATTERING, WHICH THE USUAL REAMER WILL NOT DO.

FIG. 50—GROUP OF BALL-JOINT REAMERS FOR STEAM PIPES IN STOCK, SUBJECT TO ORDER FROM OUTSIDE SHOPS.

FIG. 51—VIEW OF TWO STANDARD FLUE ROLLERS MADE IN CENTRAL TOOL-ROOM. THESE ROLLERS ARE KEPT IN STOCK SUBJECT TO ORDER FROM ALL SHOPS ON THE SYSTEM, AND INSURE ALL FLUES BEING ROLLED TO STANDARD.

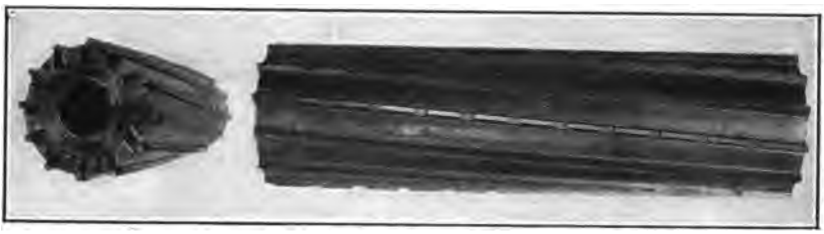


FIG. 52—MILLING CUTTER WITH INSERTED STEEL BLADES MADE IN A WELL-ORGANIZED TOOL-ROOM. THESE BLADES ARE MADE FROM FLAT TOOL STEEL, AND GROUND TO THE PROPER SPIRAL.

FIG. 53—VIEW SHOWING LOT OF SMALL PARTS, SUCH AS WASHOUT PLUGS, CHECK VALVES, GAUGE COCKS, ETC., FINISHED IN LARGE QUANTITIES AT CENTRAL SHOP AT LOW DUPLICATE PRODUCTION COST, AND FURNISHED TO OUTSIDE POINTS ON REQUISITION.

with a machinist at 35 cents an hour, and a lathe on which the hourly charges were 45 cents, would amount to about 27 cents, or a little over a dollar on four bushings for one engine. As in this case over one hundred engines were so changed, and would require new bushings at periods of about six months, it will be seen that this small item was worth the trouble expended upon it.

Percentage of Standard Equipment.

It would be absurd and immensely unprofitable to displace all existing engines with new standard ones, for the double reason that the old engines are in a majority of cases able to render good and efficient service, and that the new standardized engines would in the course of five years themselves be obsolescent. Moreover, such thorough standardization as hereinbefore indicated will apply in whole to but 30 to 50 per cent of the engines, although these engines move 75 to 80 per cent of the traffic. It can only be hoped that standardization will be approximately complete. In the course of time, and as experience and recent development dictate, these standard parts themselves must undergo re-design. But it may be hoped that for the greater part the feature of interchangeability will be retained, and the feature of central manufacture in quantities will be one of the governing considerations in design and re-design.

In new engines, therefore, the standard types and standard detail parts will of course be adhered to. In the existing engines of more modern types, where parts are worn out or broken, they will be replaced with the standard article, this standard article having been designed with reference to its applicability to the largest number of these fairly modern engines. Where parts on an engine receiving general overhauling are not in bad condition (such as a trailer wheel or a rocker arm), the old part should be retained on the engine unless it is of some notably defective design.

While on the smaller, more miscellaneous, older engines some few of the accessories and little detail parts can be applied, it will be found that extensive standardization of the larger parts, such as rods and cylinders, will not pay. As, however, the expense of general overhauling of these engines is quite low compared with that of the heavy modern power, this is not a serious disadvantage, especially as the engines are not pushed so hard in service.

When it comes to manufacturing these standard parts in the centralized shops of the railway system, the following practice should be adhered to:

Bolts and pins of all kinds should be of the fewest possible lengths, lengths of thread, and nominal diameters. Tapers, of course, should be standard. These articles cannot be furnished in one finished diameter only; but they can be furnished in a series of diameters varying by 1/32 or 1/64 inch, if tools are at the same time provided for boring or reaming to the nearest standard finished diameter. Bushings of brass and steel should be standardized in much the same manner, and can be carried, if standardization is developed far enough, in completely finished sizes, drilled. Similarly, taper plugs, studs, staybolts, and flues can be standardized, the former as to lengths, diameters, and threads, the latter as to extra lengths.

Standard Locomotive Parts.

Cylinder diameters, bushings, piston heads, and piston packing-rings can likewise be reduced to absolutely finished standard; and similarly for piston valves, rings, and bushings. Piston rods and piston-rod fittings and nuts can also be standardized as to lengths and diameters. Wedge liners can be carried in stock finished in varying thicknesses. In the same way the use of a slip wedge with the standard shoe is deserving of consideration.

With a fully developed system of ordering material at an early date in advance of an engine being taken out of road service for general repairs, and a systematic method of checking up and keeping on hand a sufficient stock at any division point, great economies will result from the carrying out, in a very extensive manner, of this manufacturing of all articles in quantities and economically, thus doing little more than applying them to the engines at the local shops.

STANDARD PARTS CENTRALLY MANUFACTURED.—After the standardization policy has been determined upon, the next work will be to decide as to the shape in which these parts will be sent to sub-stores; that is, whether as rough material or parts, or as completely finished articles. For instance, it probably would not be proper to forge and drill smoke-arch rings, and supply those for different classes of engines as finished articles, for the reason that the ring would not exactly fit the front end of an engine even though it were designed for that class, the variations being sufficient to make the ring too large in some cases, and too small in others; moreover, the holes would not correspond closely to the holes in the front end. On the other hand, such parts as valves and cab fittings should be supplied completely finished. Then again, engine bolts or knuckle pins might be partly finished, for example, being

Standard Parts to be Finished.

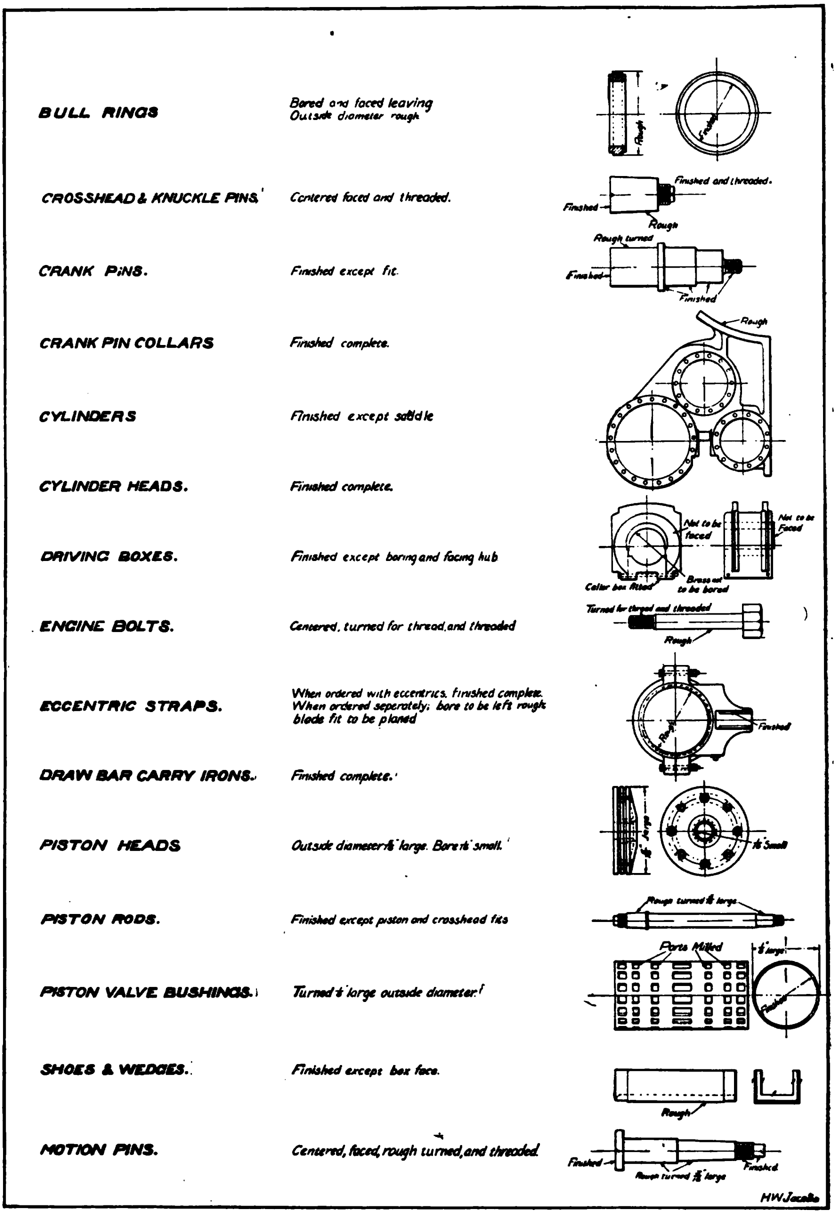


FIG. 54—PARTIAL LIST OF LOCOMOTIVE PARTS, WITH SKETCHES, FINISHED IN CENTRAL SHOP IN LARGE QUANTITIES AT VERY LOW COST. THESE PARTS ARE KEPT IN STOCK AND ARE SHIPPED TO OUTSIDE SHOPS ON REQUISITION, THUS KEEPING DOWN REPAIR COSTS AND INSURING MORE RAPID MOVEMENT OF LOCOMOTIVES THROUGH ROUNDHOUSES ON ACCOUNT OF HAVING THE FINISHED MATERIAL ON HAND READY TO APPLY.

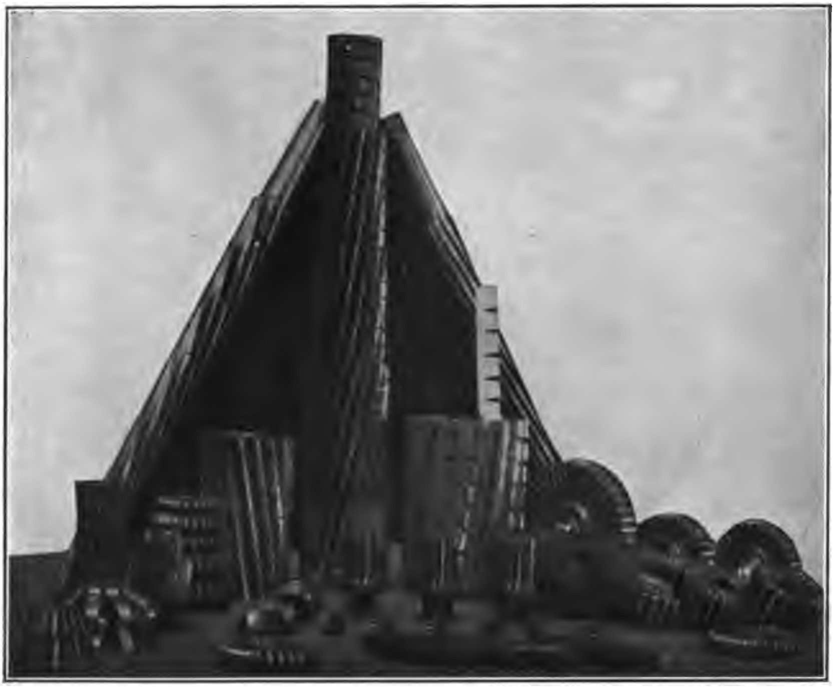


FIG. 55—TOOLS PRODUCED IN A WELL-ORGANIZED RAILWAY SHOP TOOL-ROOM. THESE TOOLS WERE ALL MADE FROM THE BEST DESIGNS AND MORE ECONOMICALLY THAN THEY COULD HAVE BEEN PURCHASED. THE SIX-INCH SCALE SHOWN IN RIGHT CENTER INDICATES THE SIZE OF THE CUTTERS.

FIG. 56—OLD METHOD OF MILLING PORTS OF PISTON-VALVE BUSHINGS. THE BUSHING WAS SET BY HAND AND ONE PORT BEING MILLED AT A TIME.

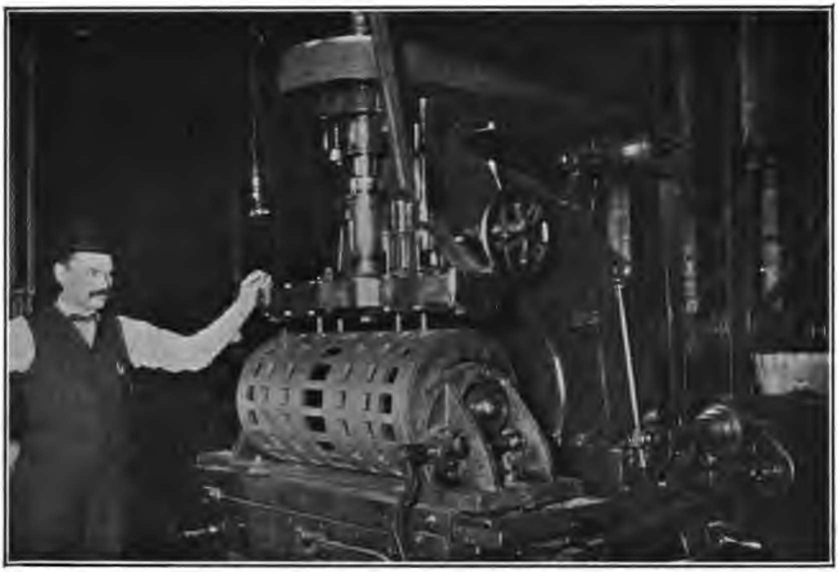


FIG. 57—IMPROVED METHOD OF MILLING PORTS OF PISTON-VALVE BUSHINGS. THE MACHINE IS EQUIPPED WITH FOUR MILLING CUTTERS AND THE BUSHING IS MOUNTED ON A MANDREL THAT CAN BE ROTATED BY A HANDLE.

FIG. 58—INSIDE GEARING OF FOUR-SPINDLE MILLING DEVICE FOR MILLING PORTS OF PISTON-VALVE BUSHINGS.

centered, cut off, and faced to length and threaded, the outside diameter being left rough to be turned to fit for each individual engine.[1]

List number two, following, gives such parts as it would be desirable to finish in whole or in part at the central shops, so that a minimum amount of work might be required to be done on these articles at the local points.

Standard Parts Finished, List No. 2.

Piston heads, bull rings, and spiders, finished complete except leaving rod fit a little small and the outside diameter to be about $\frac{3}{4}$ inch large.
Crosshead and knuckle-pins centered, faced, and threaded.
Driving boxes and collars, finished and fitted except boring the brass and facing hub.
Shoes and wedges, finished except box face.
Cylinder castings, drilled and finished complete, except at saddle.
Engine bolts, centered, threaded, and slotted for split keys where necessary;
Or, turned in varying taper diameters also, to be fitted by blocks in the local shops and roundhouses.
Piston rods, finished, except piston and crosshead fits, which are left liberally large.
Piston-valve bushings, finished to length, bored and turned, except that bushing or cage is turned a little large; and live-port openings finished.
Crank pins, finished complete except wheel-center fit.
Eccentric straps only, finished except bore babbitt.

In addition to the above list, which shows standard articles finished in part, the following articles should be finished complete:

Blower elbows.
Cylinder heads.
Crossheads.
Crank pin collars.
Chafing irons.
Drawbar carrying iron.
Double cones (dry pipe T heads).
Engine truck box.
Eccentric and straps when ordered together.
Exhaust nozzle.
Grease cups and grease-cup plugs.
Pipe glands.
Pilots and pilot bands.
Packing rings.
Pedestal binder; solid pedestal binders finished except slotting for jaw fit and drilling.
Piston valves and valve-chamber heads.
Rocker box and tumbling-shaft box.
Side rods and main rods.
Slide valves, steam chests, and steam-chest covers.
Steam pipes and stand pipes.
Stack saddles.
Safety-chain hook and swing-chain hook.
Transmission bars, except drilling for bushing.

[1] See table showing economy effected by concentration of manufacture of certain locomotive parts at central shops, p. 176.

STANDARD TOOLS CENTRALLY MANUFACTURED.

Wrenches; grease cup, car repairer's.
Machine punches.
Flue rollers.
Flue-beading tools.
All chisels and drift pins.
Sectional flue expanders.
High-speed turning and planing tools.
High-speed flat drills.
Frame reamers.
Staybolt taps.
Special devices.
All large reamers.
Milling cutters.

Besides these parts, all injector, lubricator, air-pumps, whistle, cylinder-cock, pop-valve, valve-gland, check-valve and piston rod packing parts, should be furnished completely finished. To this list should also be added blow-off-cocks and fittings, starting valves, branch-pipe unions, water-glass parts, truck and trailer brasses, oil cups and rod-cup bushings, elbow, relief valves, air and feed-hose parts and couplings, hose strainer water and lubricator-glass guards, plugs of all kinds, and all similar classes of material.

Many of these small parts can be standardized for all engines; others, again, which would vary in design from one class of engine to another, should be furnished to such engines only as it had been decided to standardize, and such other unstandardized engines as standard parts could be made to fit.

Material Supply of Local Stores.

It will be found, when this system of supplying centrally manufactured articles to local stores is promulgated, that there will be great difficulties in obtaining a satisfactory working of the system, for the reason that the foremen and others managing shops and roundhouses will not have any comprehensive idea as to the kind and amount of stock supplies they require, and even where they do have such an idea, will not have the opportunity (or take it) to submit lists to the authorities through whom the stock must be ordered.

The various storekeepers will of course do their best to keep on hand sufficient reserves of stock to supply estimated shop needs, but in this effort on the part of the storekeepers very little assistance is usually rendered by the shop managements. As a consequence, the storekeeper will often order some articles in quantities out of all proportion to consumption, and other parts, frequently needed, will be but meagerly supplied. The result is, that in some respects the local stock platforms are piled high with material which is delayed an unprofitable length of time in getting into active and useful service; and on the other hand, many delays result to engine repairs owing to the shortage of essential parts, such shortage not even being discovered

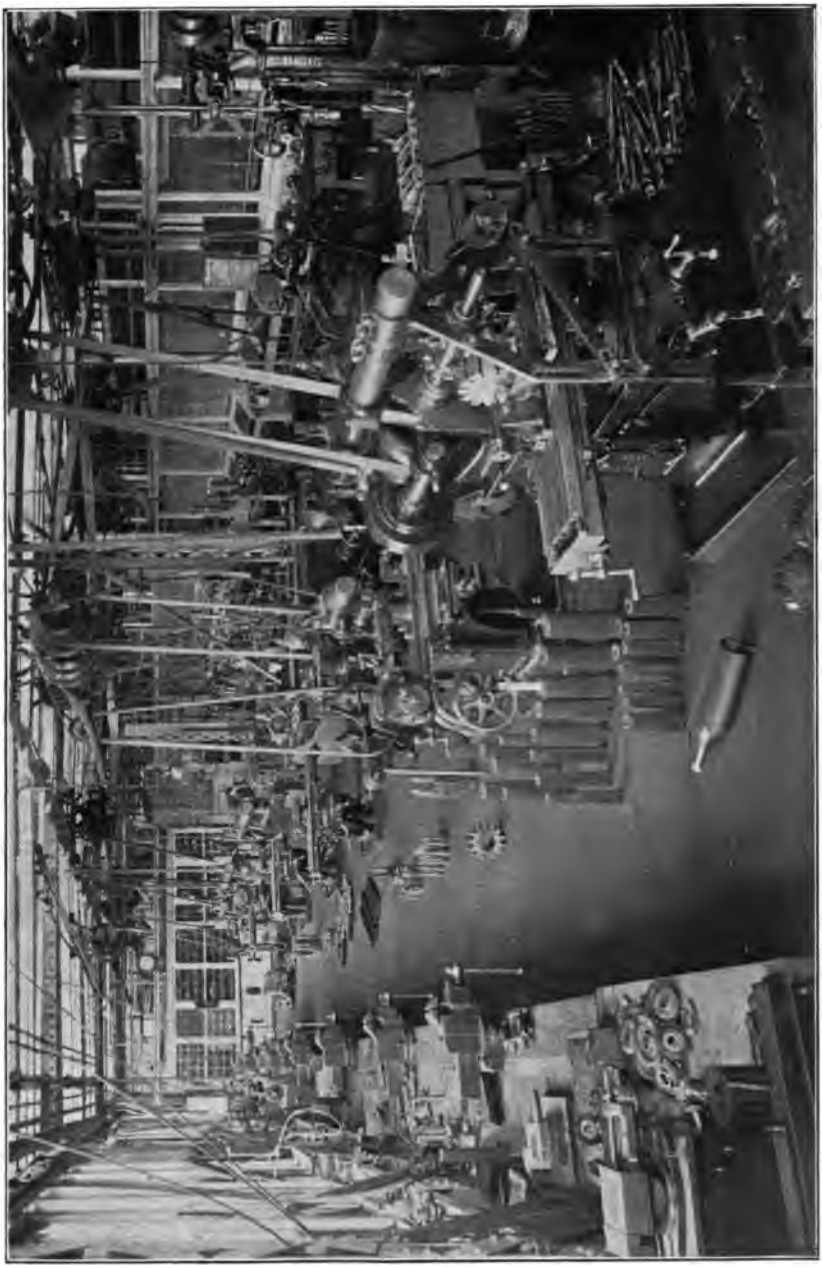


Fig. 59—A TYPICAL TOOL-ROOM FOR CENTRALIZED MANUFACTURE OF SMALL TOOLS AND DEVICES.

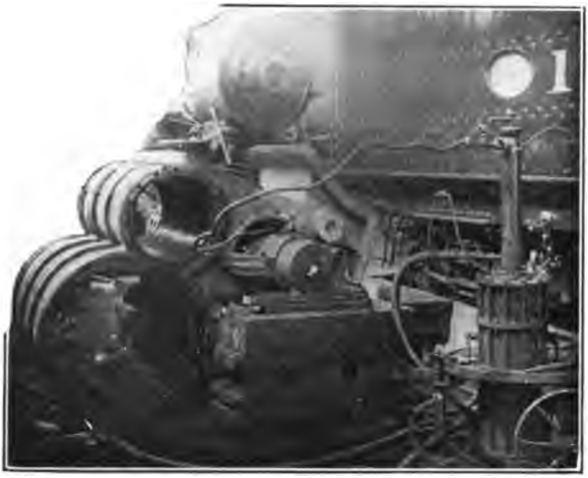


FIG. 60—HYDRAULIC MACHINE FOR PRESSING IN AND REMOVING PISTON-VALVE BUSHINGS FROM CYLINDER CASTING. DEVISED BY AN ERECTING-SHOP FOREMAN.

Total Pay Roll, 1905	$650,984.31
" " " 1906	539,390.62
Total reduction 1906	$111,593.69
Per cent. reduction	17%

Total for year 1906 includes $32,696.23 bonus paid to workmen and entire local cost for installing system, and an average increase in wages of 10% due to bonus.

Total output in tons, 1906		30,188
" " " 1905		26,924
Increase, 1906 over 1905		3,264
Per cent increase		35%
Total cost per ton (labor and material), 1905	$	14.89
" " " " " 1906	$	9.59
Decrease, 1906 under 1905	$	5.30
Per cent decrease		35%
Total output of cars, 1906		18,908
" " " 1905		18,610
Increase, 1906 over 1905		298
Average cost per car, 1905	$	15.23
" " " 1906	$	12.57
Decrease in cost per car, 1906	$	2.66
Per cent decrease		17%

Total No. Days.	Total No. Engines.	Average No. Days in Shop Per Engine.	Number Days Saved.
1905—8,641	332	26	
1906—7,628	361	21	
		5	1,805

Grant an engine day saved at $25.00. At this rate the company has saved time amounting to $45,125.00 during the year 1906.

STATEMENT SHOWING IMPROVEMENT ONE YEAR OVER ANOTHER AT ONE SHOP ON ACCOUNT OF BETTERMENT WORK. THE HEARTY COÖPERATION AND ENTHUSIASM OF THE FOREMEN IN REGARD TO THE BETTERMENT WORK WAS THE PRINCIPAL FACTOR IN THE EXCELLENT SHOWING MADE. REDUCED PAY-ROLL, INCREASED WAGES TO MEN, GREATER OUTPUT AND LESSENED DELAY TO ENGINES FROM EARNING SERVICE, AT LOWER COST.

until nearly the time when it is proposed to renew and apply the part to the engine.

The three departments—stores, mechanical, and operating—should in fact "get together" in some practical way for the discussion of mutual assistance. The operating department, seeing ahead the traffic requirements, should forecast as nearly as possib e changes in the engine assignment, both as regards the number of engines assigned to different divisions and runs, and also as regards the type of engines so assigned. The mechanical department, presumably well posted at all times on the conditions of all engines, should indicate, several months in advance, the approximate shopping dates of the engines. Knowing these two factors, it should be very easy to decide what shop would undertake the repair of each engine, and to see immediately that there is provision of the principal material which will be required on these engines, such as tires (if the limit of tire wear is exceeded), shoes and wedges, probably, bushings, packing-rings, and perhaps piston rods.

Co-operation of Departments.

The store, thus advised in advance, should be able through its organization to have the requisite material on hand before the engine is finally withdrawn from active service and repairs commenced. In fact, it should be possible in regard to some new parts, to have already completed the most of the machine work even before the engine is stripped, making the task of erecting these parts onto the engine a relatively speedy one, thus delaying the engine from earning service the least possible time.

It will be found that where this centralized manufacture is undertaken, if the railway system is not a very extensive one, the central shops will take care of the heaviest repairs, such as boiler and fire-box renewals, and shopping of engines requiring a general overhauling of two thousand dollars and up: this is on account of the presumably much more complete equipment of the central shops in regard to machine tools and methods of handling material and work, such as cranes and power rolls for boiler sheets. On a railway system that extends over a great territory between terminals, more than one such shop will be required for the heavy and expensive repairs, though in no case should there be more than one shop doing general manufacturing. In either case the method of approximately determining in advance what engines will require shoppings will enable the management to take care of the heavy repairs at the larger shops, and to apportion the light repairs at

Distribution of Locomotive Repairs.

the smaller shops in some relation to the capacity of these various shops to turn out the work economically and expeditiously. It does not pay to swamp with eight or ten engines, a shop built for an output capacity of six engines a month, as all engines will be delayed so much longer from getting into active service. On the other hand, there is a limit below which it is not economy to make haste in turning out engines.[1] These various relationships—that of the motive power to the traffic requirements, of the shops to their capability of handling repairs to motive power, and of the material and stores department to furnishing prompt delivery of material as nearly completely ready for application as is practicable—all these considerations must be intelligently gone over, and decisive action taken, in order to obtain the full benefits of the general methods here outlined.

That such careful and thorough consideration is well worth while, is shown by the fact that repairs and renewals to locomotives will average, on a railway using a large power, more than $2,000 per engine per year—anywhere from forty to several hundred per cent higher than it needs be with careful and intelligent management. Not only is this large saving amounting from hundreds of thousands of dollars to even a million or so per year, quite within reach, but an almost greater financial gain is obtainable by decreasing the time engines are kept out of service for repairs, thus increasing their earning power hundreds of thousands of dollars per year, and also postponing the necessity for tying up capital at too early a date in additional power equipment.

Cost of Locomotive Repairs.

The average railroad takes from three weeks to two months to effect a general overhauling and repairing of a locomotive; Baldwin Locomotive Works can build complete new engines in an incredibly short time —a very few days, even within twenty-four hours, it has been reported. There is little reason why some of the methods making such rapid production possible should not be in some way adaptable to railroad practice, with the result that a general overhauling would not require over a week or ten days at the outside. Of course, if shops were worked night and day on three shifts, this time of detention from service could be still further reduced, and the additional advantage would be gained that the shop capacity would be greatly increased without increased capital expenditure on buildings and equipment. There are certain

Economy in Rapid Locomotive Repairs.

[1] See article, "Locomotive Repair Schedules," by C. J. Morrison, in American Engineer and Railroad Journal, September, 1906.

disadvantages in working the men in shifts in this manner, but the financial benefits are so great as to make the plan well worth considering in respect to the larger shops, especially where extensions of plant are proposed.

III. CENTRALIZATION AND BALANCE OF MACHINE TOOL EQUIPMENT ON AN ENTIRE RAILROAD.

A railroad of the size with which we are dealing in these articles will have a number of lesser shops besides one or more large main shops. These lesser shops will be under different master mechanics, and each one will be provided with a machine tool equipment, usually collected and added to during a long period of years. Many of these machines will be old, some will be new, and it will come about that fine and expensive machines, rarely used, will by chance rather than by intelligent foresight be found in small shops.

Each master mechanic, in order to lessen the burden of "grief" upon him in the way of power tied up for repairs, naturally desires to fortify himself as far as possible with a large and safe number of men and a full and complete shop-tool equipment. As master mechanic succeeds master mechanic, different items will receive attention, and the shop will be strengthened now here, now there. One man will devote his attention to the roundhouse and clamor for efficient drop pits, overhead cranes, lighting and heating systems. His successor will yearly add many thousands of dollars to the machine-tool budget—large radial drill suitable for use with mud rings, a quartering machine, some patent planer or grinding machine, electric drives, or what not. Still a third will insist on all manner of small tools, abrasive wheels, air motors, valve-setting machines, jigs and devices without number; usually he has these made right in the shop, and the expense does not appear on the budget nor in the requisitions, but totals up in the payroll.

Variation in Policy of Mechanical Officers.

The result of this general attitude and policy on the part of the master mechanic of a division, wherein he is ably seconded and supplemented by all the foremen under him, is that the lesser shops are usually over-equipped and over-manned for the amount of work they are supposed to turn out. The higher officials, in charge of the purse-strings and the budget, exercise quite a restraining influence, and keep this over-equipment from reaching extravagant proportions. A master mechanic has too much dependent upon him, in the way of keeping

engines in running condition and supervision of roundhouses over his division, to give close study to the question of whether the installation of certain machinery is economical, and he is often influenced by the urgency of his foremen in such matters; at the same time the higher officials must in large measure rely upon the master mechanic's recommendations, as he is the man employed to look after such interest, and they usually have no other means of determining the requirements.

When, therefore, it has been decided by the management of a railroad to organize thoroughly and to systematize clear-sightedly their mechanical department, one of the earliest moves, after the general policy of centralization of manufacture and standardization of parts has been worked up, is to take stock of the entire shop and tool equipment of the road, and to decide upon certain broad policies in regard to the economical utilization of this equipment. Under the general plan of centralized manufacture herein outlined, it is very probable that the main shops will have to be enlarged and that their tool equipment will have to be increased. Instead, however, of purchasing large amounts of new machine tools, it will be found of great advantage to transfer to the main shops needed tools spared from the outlying shops. Of course this policy will be bitterly opposed, but it needs no argument to show that a $10,000 wheel lathe is better off in a place where it can turn out seven to ten pairs of drivers a day, than where the total shop output would permit of turning but one or two pairs; and it also needs no argument to show that it would be folly to purchase an additional new machine for the large shops when one of which so little use was being made, was available. I cite this case because it happens to be an actual one. The same rule should govern in the case of engine lathes, boring mills, slotters, and especially, large milling machines and special grinding machines.

Economical Utilization of Tool Equipment.

Increased Production from High-Speed Steel.

One of the great factors of shop production improvement is the modern high-speed alloy steel, by the use of which many machining operations can be greatly reduced in time.[1]

This first view is of the noses of two large planer tools, the one on the left of carbon tool steel, and the one on the right of high-speed alloy steel. Besides each tool is the chip that it removed from a main rod in five seconds. The cutting edge of the carbon tool was burnt as shown after three minutes' service; the other tool kept the edge here

[1] See report of tests with high-speed steel, pp. 53-57.

FIG. 61—RESULTS OF TEST OF CARBON *vs.* ALLOY STEEL TOOLS, SHOWING COMPARATIVE METAL REDUCTION AND CONDITION OF TOOL NOSES WHICH ARE CUT OFF FOR THE PURPOSE OF EXHIBITION. SIX-INCH RULES ARE SHOWN IN EACH ILLUSTRATION. THE HIGH-SPEED TOOLS AND CHIPS ARE IN THE MIDDLE AND THE CARBON TOOL AND CHIPS ON THE OUTSIDE. THE CHIPS ARE IN IN EACH CASE THE RESULT OF FIVE SECONDS' CUTTING.

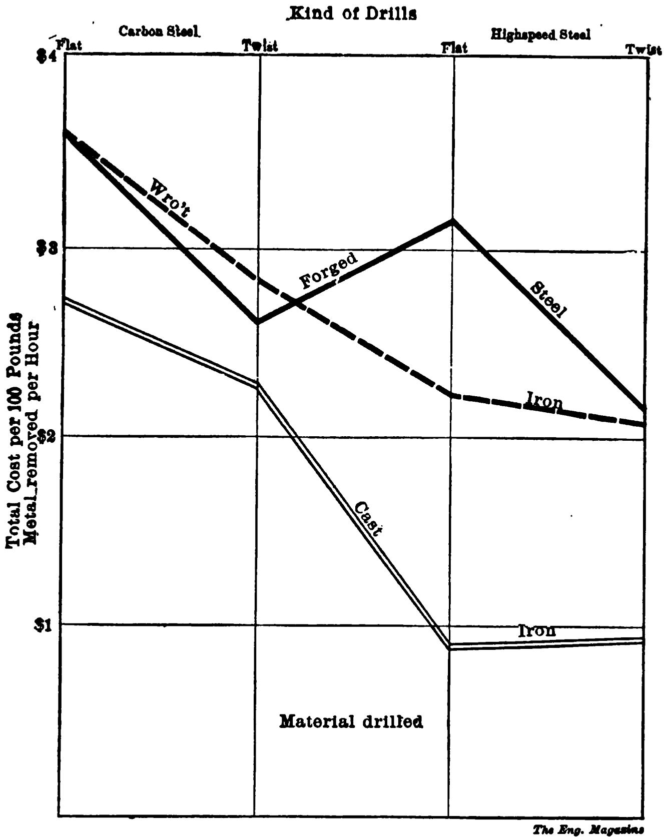


FIG. 62—COMPARATIVE EFFICIENCY OF FLAT AND TWIST DRILLS MADE OF CARBON AND HIGH-SPEED STEEL.

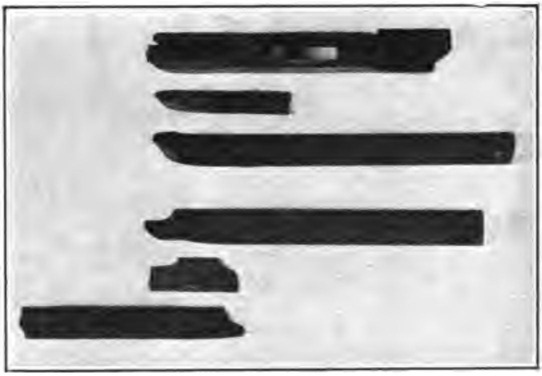


FIG. 63—SIZE OF SOLID HIGH-SPEED WHEEL-LATHE TOOLS COMPARED WITH THOSE USED IN TOOL-HOLDERS.

FIG. 64—"PHANTOM" VIEW OF WHEEL-LATHE TOOL-HOLDER, SHOWING CUTTING TOOLS IN PLACE.

FIG. 65—VIEW SHOWING THE RELATIVE AMOUNTS OF STEEL REQUIRED FOR WHEEL-LATHE TOOL EQUIPMENT UNDER OLD AND NEW CONDITIONS.

FIG. 66—PILE OF SELF-HARDENING AND CARBON-STEEL TOOLS, WITHDRAWN FROM USE WHEN STANDARD HIGH-SPEED TOOLS ARE GENERALLY INTRODUCED.

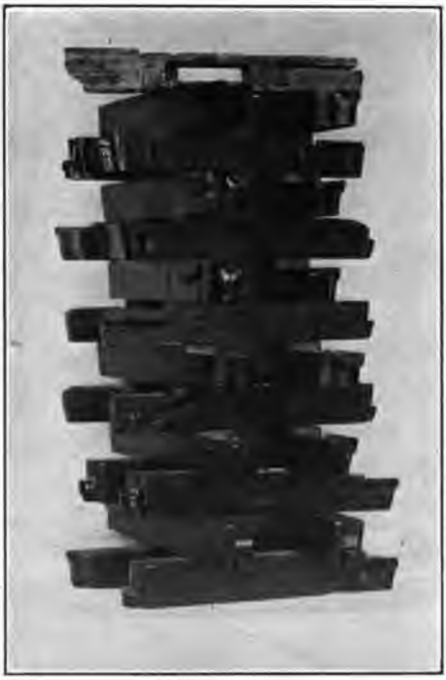


FIG. 67—A STACK OF WHEEL-LATHE TOOL-HOLDERS READY FOR SHIPMENT TO OUTLYING SHOPS.

FIG. 68—AN EFFICIENT CENTERING MACHINE DESIGNED AND BUILT IN THE SHOPS. IT COSTS LESS AND IS QUICKER IN ACTION AND MORE ACCURATE THAN ANY MACHINE TO BE FOUND IN THE OPEN MARKET.

photographed for an hour and a half, removing 780 pounds of metal per hour, and was still not in need of grinding.

When the high-speed alloy steel was first put on the market its fiery-furnace ordeal was to stand up under the severest conditions that turning tires on the wheel lathe would subject it to. While experimenting with these steels on the wheel lathe on Krupp tires, it was found that the usual wheel-lathe tools were inefficient in design and needlessly heavy in the amount of tool steel used. To economize in the tool steel, and to standardize the flanging tools, a cast-steel holder, using only 1-inch square by 3 inches, and a flat flanging cutter ⅝-inch by 2 inches, instead of a 1½-inch square bar, was designed. The old flanging cutters were forged and shaped and then ground by the machinist according to his ideas as to what the shape of the flange should be. The new flat cutters, weight not one-tenth as much, were milled out to standard M. C. B. shape in the tool-room, in quantity, and then hardened. They retained their edges under test about twenty times as long as the old tools, and when in need of new grinding were reground in the tool-room to standard. The illustration shows the flat cutter flanked on each side by the two large flange cutters necessary under the old conditions, and shows also the old roughing tools, the new small roughing tool, and the cast-steel tool-holder. The high-speed steel used in these two tools weighs only 3 pounds, as compared with 27 pounds for the old set. The saving of 24 pounds at 50 cents per pound, where these sets of tools are kept in duplicate or triplicate, for each shop having a wheel lathe on a railroad system, will amount to a considerable sum of money—secured by the use of a cast-steel tool-holder, costing less than $1.[1]

Improved Wheel Lathe Tools and Holder.

Possible Savings in Tool Steel.

The tool accounts on our larger railroads run from $100,000 to over $1,000,000 per year. When necessary expenditures for new machine-tool equipment are cut out, when needless manufacturing of small and special tools is stopped, and the tool-room force at the small shops so reduced that it is not possible to spend time and wages on such manufacturing in addition to keeping up the ordinary repairs and care of tools, and the pay-roll of the tool account is checked up for each point each day, and summarized each month, it will be astonishing what reduction in this tool expense can be accomplished, without any detriment to the service, but on the other hand, with increased efficiency resulting

Cost of Machinery Maintenance.

[1] See p. 24 for detailed drawing of wheel-lathe tool-holder.

from intelligent supervision and supply of what is needed most in order to get the work out. It may be confidently stated that if this tool proposition is handled thoroughly, radically, and uncompromisingly, the account may assuredly be cut in two.

We deal here in economies in tool equipment; by means of tools alone can we maintain our power. The tool account will not be 5 per cent of the whole cost of maintaining and renewing locomotives, yet where a 50 per cent tool account economy can be made, a 20 per cent engine-repair economy is also possible, with better engines, turned out more quickly. It is with these larger and more telling economies that we have chiefly to deal.

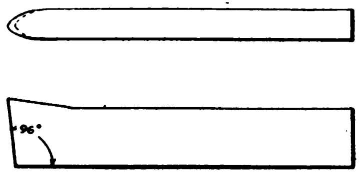
Possible Reduction in Tool Account.

Considerations Governing the Selection and Design of Machine-Tool Equipment.—Whenever a large shop is built, or even a small shop extended, everyone, from the machinist to the highest officials on the road, considers it desirable and advantageous to purchase and put into use the best modern machine tools that can be had. In fact, there is a constant tendency toward the acquisition of these new machines. We have already shown how ill-chosen in respect to the needs of a shop these purchases often are; here stress is to be laid on the fact that most of this new machinery is neither necessary nor desirable.

With the prosperous conditions existing all over the United States in the past five years, extravagance and wholesale expenditures have seemingly become rampant, not only in government and municipal undertakings, but also, concurrently with the rapid rise of consolidated industries, in the new and improved equipment necessary to carry these on in an economically centralized way. In general this policy of expansion in manufacture and centralization, and of acquiring equipment enabling such concentration, is according to economic laws; but in detail, much of this hue-and-cry about new machines and modern methods is a fad. For instance, we have many advocates of individual electric drives for machine tools. Electric cranes, electric telfers, and other electrical devices are considered very desirable, and great savings in labor are claimed on their account. Similarly, big, heavy new machines are thought essential for several reasons. Much that is being done in this direction is not economical—quite the contrary—and better results would be secured if closer attention were given toward

Tendency Toward Extravagance in Purchase of Tools.

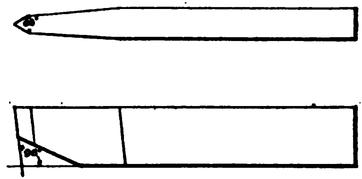
Lathe Tool



Symbol	Size inches	Symbol	Size inches
L-8	½ x 1 x 8	L-126	¾ x 1¼ x 9½
L-10 a	⅝ x 1⅛ x 8½	L-14	⅞ x 1⅛ x 10
L-10 b	⅝ x 1¼ x 8½	L-16	1 x 2 x 12
L-12 a	¾ x 1⅛ x 9	L-20	1¼ x 2 x 14

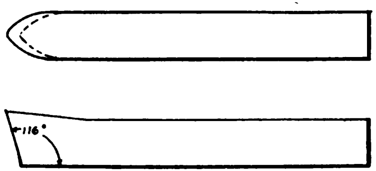
Material: Highspeed Steel

Straight Threading Tool



Symbol	Size inches	Material:
T-8	½ x 1 x 8	Highspeed Steel
T-10	⅝ x 1⅛ x 8½	
T-12	¾ x 1¼ x 9	

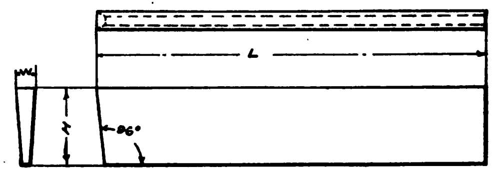
Boring & Turning Tool
Used with Patent Holder



Symbol	Size inches	Symbol	Size inches
B-4	¼ square x 2½	B-12	¾ square x 3¾
B-5	5/16 " x 2½	B-14	⅞ " x 4½
B-6	⅜ " x 3	B-16	1 " x 8
B-7	7/16 " x 3	B-20	1¼ " x 8½
B-8	½ " x 3		
B-9	9/16 " x 3¼		
B-10	⅝ " x 3¾		

Material: Highspeed Steel

Cutting Off Tool.
Used with Patent Holder



Symbol	Size inches W x H x L	Symbol	Size inches W x H x L
C-10	3/32 x ⅝ x 5½	C-16	3/16 x 1 x 8½
C-12	⅛ x ¾ x 6½	C-18	3/16 x 1⅛ x 9½
C-14	⅛ x ⅞ x 7½	C-20	¼ x 1¼ x 10½

Material: Highspeed Steel

FIG. 69—EXAMPLES OF STANDARD SHAPES OF TOOLS FOR VARIOUS MACHINES. THE TOOLS ARE MADE TO TEMPLATES, THUS INSURING EXACT ANGLES, CLEARANCE, ETC. A SYMBOL NUMBER IS ASSIGNED EACH TOOL, WHICH IS USED IN ORDERING. THE SYMBOL INDICATES THE KIND OF TOOL, AND THE WIDTH OF THE BAR STOCK IN SIXTEENTHS OF AN INCH.

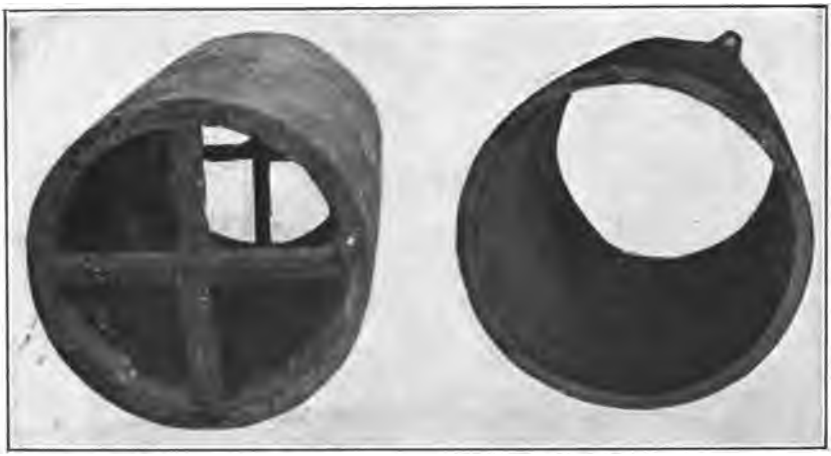


FIG. 70—OLD AND NEW PATTERNS OF CYLINDER BUSHINGS. THE FORMER WAS DESIGNED WITH CROSS-IRONS FOR TURNING UP IN A LATHE BEFORE BORING. THE LATTER CAN BE BORED FIRST AND TURNED UP ON A MANDREL IN A LATHE LATER. NOTE THE SAVING IN STOCK AND MACHINING BY THE INTELLIGENT DESIGN OF PATTERNS.

the adaptation and rebuilding of old machines with reference to the particular work in view. First, the new machines are built with such regard for massive strength that their cost is much higher owing to the weight of the material alone, and they are too heavy and cumbersome to yield rapid production. Second, notwithstanding that these machines are built with great strength, and, apparently, for very heavy service, they are still supplied with cast-iron gears, for the most part incapable of transmitting large loads for any length of time. Third, many of them are supplied with electric motors on the theory that a greater and more gradual variation in speed and power and application will be effected, irrespective of the cost or actual advantage in this method of drive. Fourth, the economical aspect of the machine-tool proposition does not seem to have been considered in a sufficiently comprehensive way, and the "surcharge" or overcharge on the machine is largely neglected in estimating its time and output capabilities.

Purchase of New Machinery Not Always Economy.

Surcharge on Machinery.

Under "surcharge" are included the following items:

Interest on the first cost of the machine.

Depreciation of the machine.

Annual repairs on the machine, including repairs to the electric motor.

Cost of horse-power delivered at the spindle.

The machine's percentage chargeable to the individual machine, or

Cost, interest, insurance, depreciation, et cetera, annual rent of the building and its appliances in which the machine is situated.

Similar percentages on the power-house equipment.

Percentages also of the supervision, clerical, and other office costs in connection with the machine.

All these items, as a rule, bear some direct ratio to the size and first cost of the machine tool, and as a consequence the overcharges are very high on some of our fine, modern heavy equipment—so high, in fact, that it is more economical to turn a pair of drivers in three or four hours on an old wheel lathe, even where the machine is used most of the time, than to reduce the time to an hour or two hours by the use of a magnificent $10,000 machine.

These overcharges are no imaginary items, appearing only on paper, but considered in an ultimate way they are actual costs, for the "gen-

eral expense" of which they represent a subdivision is a large item in any enterprise.[1]

In many cases, therefore, better results and greater economies can be secured by close attention to the rebuilding of old machines. In general it may be said that steel gears should be substituted for cast iron, wide cone pulleys used (with perhaps fewer steps), and many devices and appliances should be furnished in order to expedite and add to the convenience of the work. Along with this re-design of the machine, of which we shall consider a few detail examples shortly, comprehensive attention should be given to the condition of the line shafting, pulleys, and belting. Good forms of standard shaft hangers and bearings should be adopted; good forms of pulleys and standard belting specified. The oiling arrangements for the shafting should be made convenient and some regular system of attending to them adopted.

Suggestions for Improving Machine and Shop Practice.

The condition of the belting determines very largely the efficiency of the machine, making very considerable difference in the producing capacity of a whole shop. Therefore this small item deserves all the attention required to maintain it in very high efficiency. It is the more desirable to do so as efficient belting inspection and repair costs less than one-third as much as the ordinary practice.

Modern Shop Belting Methods.

The three pictures on the right of the illustration show the various short connecting lengths kept by a belt inspector, to take up slack. The long piece is put in first, and as the belt stretches, the other pieces are substituted in turn. The picture on the left shows a contrast to this good belt fastening.

In one of the largest locomotive works in the world I saw this fastening used less than a year ago, so that it is evidently common, very common, practice. It is, however, very inefficient, because the joint is much weaker than the rest of the belt, and because the mode of fastening tears the belt.

Roughly, the cost of belting, maintenance, etc., is between 1 per cent and 2 per cent of the pay-roll cost of running the machine shop; I have seen not less than three instances on a large scale of this cost being reduced to one-quarter of one per cent. However, I would emphasize the matter of attention to belting, not so much from the saving in the cost of the belting itself as on account of giving a better service to the general machine equipment.

[1] See article, "The Surcharge Problem," by C. J. Morrison, in American Engineer and Railroad Journal, October, 1906.

FIG. 71—A WRONG METHOD OF PREVENTING BELTS SLIPPING BY COATING THE FACE OF PULLEYS WITH ROSIN.

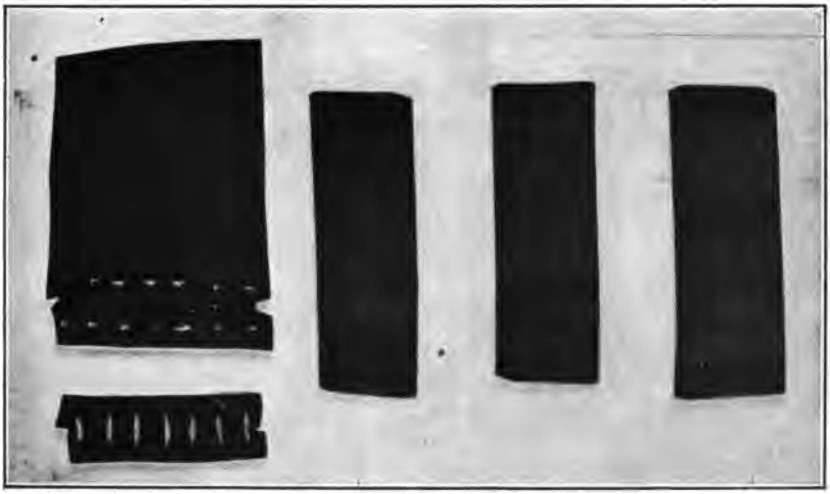


FIG. 72—THE COMMON METHOD OF BELT FASTENING WITH BRASS CLEATS AND THE MORE EFFICIENT AND ECONOMICAL SPIRAL WIRE LACING HINGING ON A RAW-HIDE PIN. UNIT-SHORTENING SECTIONS OF VARIOUS LENGTHS ARE SHOWN READY TO APPLY.

FIG. 73—HIGH-SPEED TOOLS AND TOOL-HOLDERS ARRANGED TO SHOW THE SAVING IN STEEL BY THE USE OF HOLDERS OVER THE OLD-STYLE SOLID TOOLS.

FIG. 74—OLD AND NEW STYLES OF LATHE TOOLS COMPARED, TO SHOW THE SUPERIORITY OF THE LATER DESIGNS IN STRENGTH AND SUPPORT DIRECTLY UNDER THE CUTTING NOSE. NOTE THE WEAKNESS OF THE OLD "GOOSENECK" DESIGN AT THE POINT IT SHOULD BE STRONGEST.

After these general improvements of shafting, pulleys, belting, and strengthening of machines have been started, the next step is to speed up the line and counter shafts by using larger driving pulleys. As a result of such a general move the machines will all run more rapidly from this cause alone, and an increase in production will result, of which generally the men are unconscious, especially when the changes are made Sundays and nights. Were they conscious of any organized effort toward increasing the output they would probably spend much time and thought in an attempt to circumvent such a plan.[1]

Speeding up Machinery.

While these changes may be said to be going on overhead, concurrent efforts should be made with regard to equipping the machines with such steady rests, angle plates, special bolts, dogs, chucks, and the like, air hoists and clamps, as will benefit the character of the work on each machine, and also the cutting tools should be standardized and the machines well provided with them.

Special Machine Equipment.

High-speed steel will of course be very extensively used. As the capabilities of these new steels are not fully understood by some of the men when they are first brought into the shops, there is some difficulty in getting them to dispense with their old tools. A way to enforce the use of the rapid-reduction tools is to scrap, or take out of service, every old tool.

The illustration shows an example of standardized tools.

The diamond-pointed, curved, gooseneck shape, weak and unsupported where it should be strongest and best supported, was very common in our shops, and a standard style, five years ago. In fact, at the present day this tool may be seen in use in many shops. Recently I noted in passing through the instruction shop of an engineering college that the young men were being taught to forge and grind their tools in this way. In contrast to this poor design, note the modern design of round nose, most efficient in cutting action, enabling a large chip to be removed, and well supported by the tool post.

Old and New Lathe Tools Compared.

By means of these general machine improvements alone, which with intelligent direction will not increase the cost of the tool account at all, but will, in fact, enable it to be reduced even while these wholesale improvements are being carried forward, a great increase in shop efficiency will result, without stirring up any labor difficulty.

[1] See illustrations on pp. 39, 135, showing increased feed cone pulleys after high-speed tools were adopted.

A detail example of machine re-design is here given. The illustration on p. 118 shows on the left the old method of supplying cylinder bushings. The casting is much too heavy, and the cross-arms, made so that the bushing could be centered in a lathe and turned off previous to boring, were quite difficult to cast. The bushing on the right is much cheaper to make.

Example of Machine Re-Design.

The old method of housing a bushing after it had been turned in the lathe so it can be bored in a horizontal mill is shown by the accompanying illustration. This large wooden block, for use with each size of bushing, is a very clumsy and unsatisfactory contrivance. The housing with set screws shown below was therefore devised and gave good satisfaction, as the work could be accurately centered for boring and then mounted on a mandrel and turned up in a lathe. So soon, however, as high-speed steel tools were used in the horizontal boring mill it was found that this new housing was not sufficiently rigid, and a more substantial one was designed, which stood up to all the requirements.

Changes in the Design of Housings.

Then, however, the strain on the machine was so great that the belt would not pull the cut that the tool was able to stand, and a heavier and wider belt had to be provided. In order to use the wide belt, the four-cone pulley was displaced and a three-cone substituted.

Substitution of Wider Driving Belt.

It was found that the cast-iron worm gear ran hot under these heavy cuts, and a bronze gear was made to take its place. The cast-iron gear is shown in the lower left-hand of the picture, the bronze gear up in place. When the machine was thus re-designed for use in heavy work it developed that the electric motor was not sufficiently powerful for the purpose, and one of twice the horse-power had to be then put in place. This displaced motor is shown on the floor.

Final Changes and Finished Machine.

This series of improvements resulted in a much better machine than could be bought upon the open market, and they cost less than a new machine built to order by any outside manufacturing concern.

Speaking of high-speed tools: it soon becomes evident when these heavy service tools are introduced in a shop, that many, in fact most of the machines, are not up to the capacity of the tools. Line shafts are speeded up, and driving pulleys enlarged. It is then found that the feeds, too, must be increased, to take full advantage of the cutting qualities of the new tools.

It was found necessary to make a number of changes in the large

Fig. 75—The original wooden housing for cylinder bushings used in connection with boring mill.

Fig. 76—The first improvement made in the boring mill. Cast-iron housings with adjusting screws took the place of the old wooden blocks for holding the bushings.

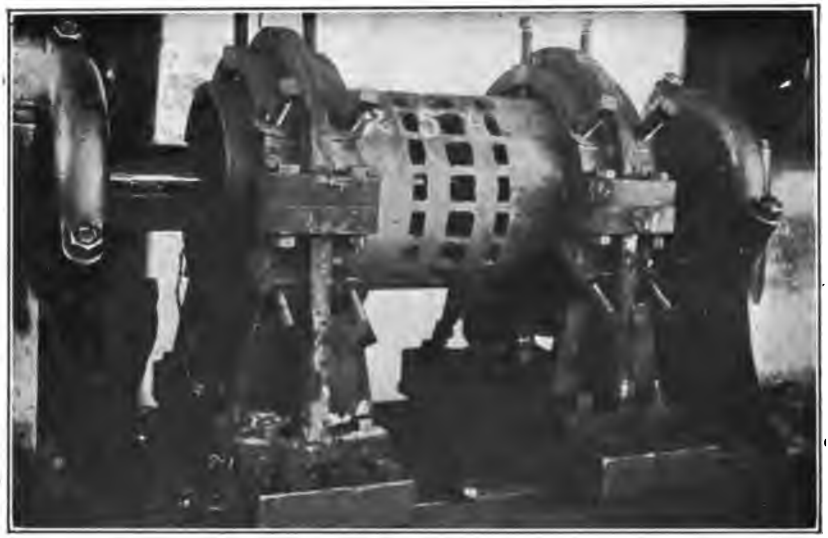


Fig. 77—The housings were re-designed as shown, after the introduction of high-speed tools, in order to obtain sufficient strength and rigidity to withstand the heavier cuts.

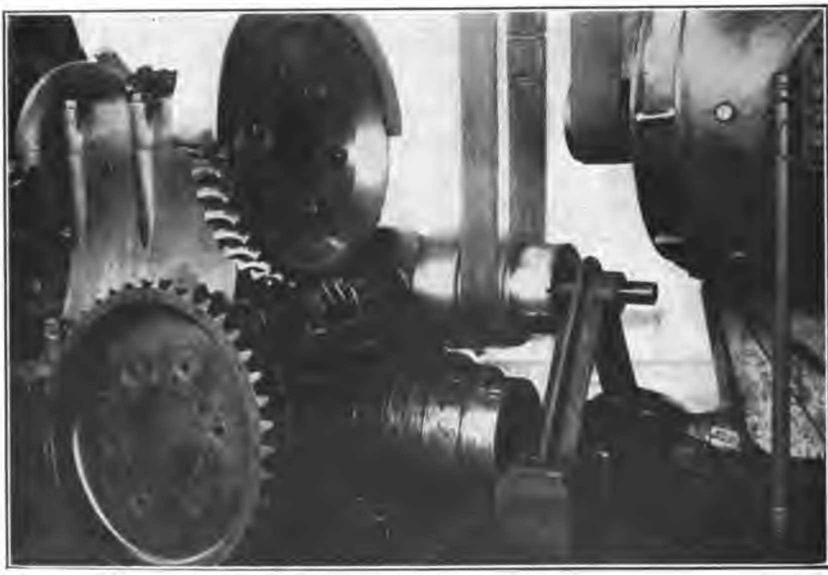


Fig. 78—Bronze worm gear that took the place of a cast-iron gear which failed under the heavy service of high-speed tools.

FIG. 79—THE RECONSTRUCTED MACHINE. THE CAPACITY OF THE MACHINE WAS DOUBLED BY THE IMPROVEMENTS MADE, AND THE ORIGINAL MOTOR WAS REPLACED BY ONE OF TWICE THE HORSEPOWER.

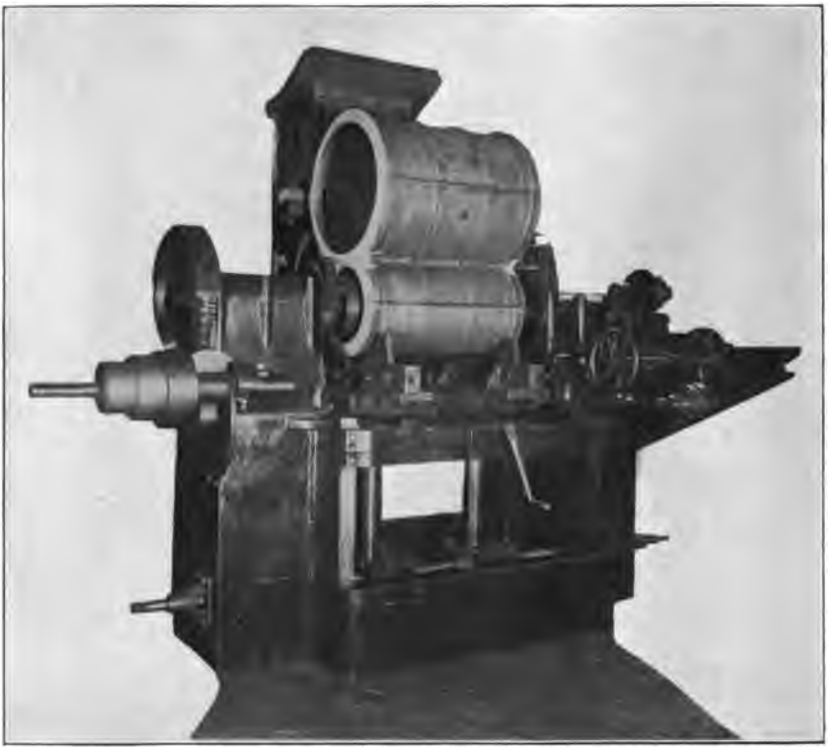


FIG. 80—LATER IMPROVEMENTS IN THE DESIGN OF THE MACHINE WERE MADE WHICH GREATLY IMPROVED ITS STRENGTH, CONVENIENCE OF OPERATION AND OUTPUT.

Fig. 80*a*—The final development of the machine. In its present condition, this machine is the superior of any cylinder-boring mill manufactured or on the market, for doing the particular class of work it was designed for. The total cost of the machine was very much less than the purchase price of a commercial tool.

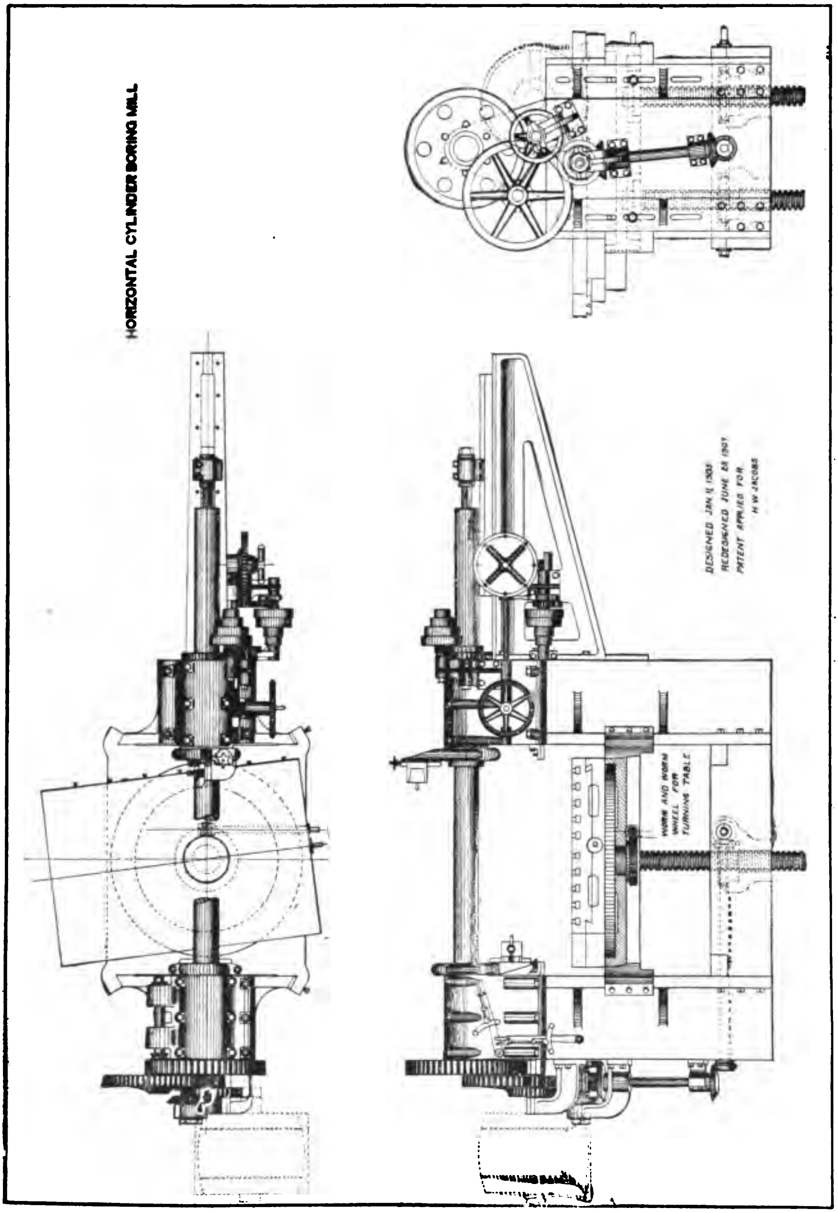


FIG. 80*b*—GENERAL ELEVATIONS OF THE IMPROVED CYLINDER BORING MILL.

frame planer shown. When this machine was speeded up and heavy cuts taken with high-speed tools, the driving-gear stripped off a tooth at one time or another. Teeth were in some cases inserted, as shown in white on this picture, and in other cases pegs were tapped in. It was finally decided to put in a steel gear, but as it would have taken several months to send to the foundry and secure a steel casting as required, a cast-iron center was hurriedly ordered and a steel band forged in the smith shop, and machined and shrunk as shown in the accompanying illustration. Some idea of the capacity of the reconstructed planer will be gained from the photograph taken while planing steel castings, using a 7/32 in. feed with both heads.

Improvements Made in Large Planer.

The substitution of a large for a small feed cone pulley on a bolt lathe in order to increase the feeds in addition to the speed was made as shown by the illustration. When it is remembered that the main-line shafts of the shop were speeded up 50 per cent and the pulley driving the countershaft for this particular lathe 30 per cent in addition, upon the introduction of high-speed steels in this shop, the additional rapidity incident to the use of this feed cone pulley will be appreciated.

Increasing Lathe Feeds.

In the early stages of the development of the high-speed alloy-steel tools, it was realized that the physical properties of these steels, in affording material for tools capable of greater cutting speeds, feeds, and cuts, would react upon the machine tools themselves, and, in the case of new machines, necessitate improved design, and adaptation to the new conditions in the case of old machines, requiring re-design of some parts and reconstruction. Of course with the new steels greater strains are encountered than those for which the machines had been designed. Now it is a fact that so far there have been very few recently designed machines turned out by the manufacturers which are altogether adapted and suitable for use with these new tools, notwithstanding the very pertinent observations and suggestions of Mr. Oberlin Smith and of the early users and advocates of the new steels. Besides this condition, the original commercial machines, when put into a railroad shop, are not always suited to the work they are to do. A gang drill will be strongly advocated by some agent on account of the speed with which it can do certain classes of work, and the master

Influence of High-Speed Steel on Machine Design.

mechanic or other officer having charge of the local shop, being much impressed with the argument, will ask for such a machine on his budget, unmindful of the fact that the classes of work on which this machine can be economically used will not occur more than once or twice a month. Had the money thus invested been spent for a thoroughly substantial and modern radial drill, or for general improvements and repair of all of the rest of the shop drilling equipment, much larger returns in economies of shop production would have resulted. Of course I do not mean to say that in a very large centralized railroad shop a gang drill would not be a useful and a profitable acquisition. I am referring to the usual railroad back shop.

Improper Selection of Machinery.

Another instance of a special tool supposed to be of great economy is that of a large hydraulic flanging press and adjacent annealing furnace, purchased with the intention of pressing from the steel plates, throat sheets, door sheets, fire-doors or fire-door flanges, front-end rings and front-end doors, cylinder-head casings, and even steam-dome flanges from 1½-inch metal. For each of these different parts separate dies or formers have to be made, these being manifold in number for each of the principal classes of locomotives in service, and furnace, an investment of $30,000 to $40,000 was sunk in these various formers. To set the machine up for flanging or pressing out any article required from two to ten hours' time of a skilled mechanic, helper, and a couple of laborers, besides the services of a gang of laborers to bring the heavy formers into the shop from their storage place. Once the machine was set up, of course the flanging would be done quite rapidly, and with relatively few, though skilled, men. But when it is considered that (1) these large articles are not usually required in quantity, (2) the formers often crack and new ones have to be made, and in any case are very difficult to adjust, and (3) above all, that a sum not far from $50,000, meaning an interest charge (at 6 per cent) of a dollar for every work hour in the year, not to speak of cost of power consumed and various repair charges to the machines themselves, it will be seen that for even a large centralized railroad shop the old-fashioned gang of boiler-maker flangers with their wooden flanging mallets and simple slab-formers, in addition, perhaps, to a modern oil-annealing furnace, would be much more economical.

Poor Judgment in Selection of Special Tool.

I have cited these two cases simply as an illustration of the point that fitness to the product in view is not the ruling motive of the sellers

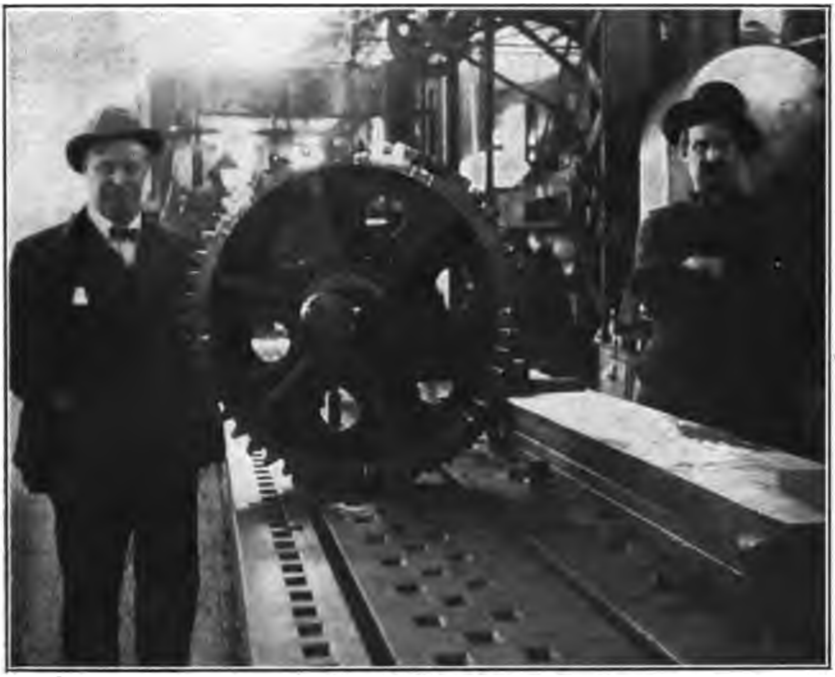


FIG. 81—A LARGE FRAME PLANER AND ITS OLD CAST-IRON DRIVING GEAR THAT WAS NOT STRONG ENOUGH TO WITHSTAND THE HEAVY CUTS TAKEN WITH HIGH-SPEED TOOLS. ON THE RIGHT IS THE MECHANIC WHO PUSHED THIS MACHINE UP TO THE LIMIT, AND THE LEFT THE PROGRESSIVE FOREMAN WHO HAS DONE MUCH IN AN ENERGETIC WAY TO INTRODUCE MODERN METHODS IN A RAILROAD SHOP.

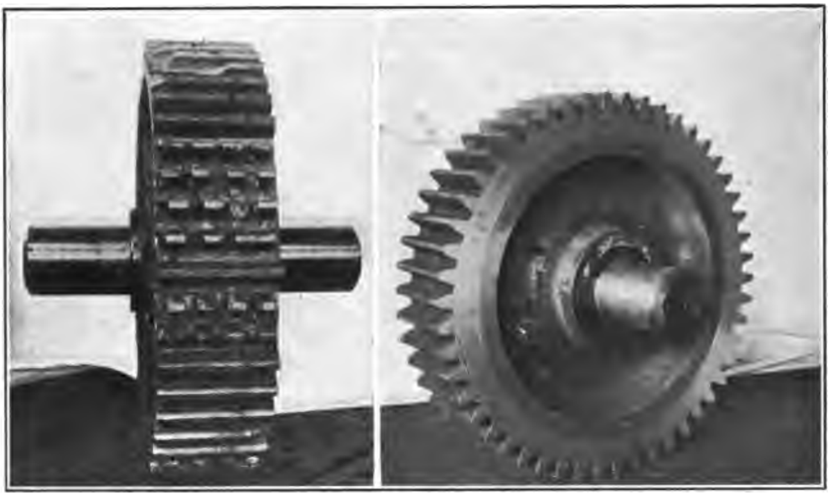


FIG. 82—THE OLD AND NEW DRIVING GEARS FOR FRAME PLANER. THE ONE ON THE LEFT IS THE ORIGINAL GEAR OF CAST-IRON. THE FAILURE OF THIS GEAR UNDER THE HEAVY DUTY IMPOSED BY HIGH-SPEED TOOLS IS SHOWN IN THE LARGE NUMBER OF BROKEN TEETH. THE NEW STEEL-RIMMED GEAR SUBSTITUTED FOR THE OLD ONE, IS SHOWN ON THE RIGHT. THE HUB IS OF CAST IRON AND THE RIM OF STEEL FORGED IN THE BLACKSMITH SHOP, AND SHRUNK ON. THE GEAR THUS MADE IS AS SERVICEABLE AS ONE OF ALL STEEL, AND MUCH CHEAPER.

FIG. 83—THE RECONSTRUCTED PLANER TAKING A $1\frac{7}{16}$-IN. CUT WITH $\frac{7}{32}$-IN. FEED ON STEEL CASTING. THIS GIVES A GOOD IDEA OF THE CAPACITY OF THE MACHINE AND WHAT MAY BE ACCOMPLISHED BY A PROGRESSIVE SHOP ORGANIZATION IN THE BETTERMENT OF MACHINE TOOLS.

FIG. 84—VIEW OF BOLT LATHE SHOWING THE INCREASED SIZE OF FEED CONE PULLEY AFTER HIGH-SPEED TOOLS WERE ADOPTED.

FIG. 85—VIEWS SHOWING THE INCREASE MADE IN SIZE OF FEED GEAR ON AXLE LATHE AFTER THE ADOPTION OF HIGH-SPEED TOOLS.

FIG. 86—BORING MILL EQUIPPED WITH CHAIN DRIVE. AN IMPROVEMENT MADE BY A MACHINE FOREMAN THAT HAS RESULTED IN A GREATLY INCREASED OUTPUT FROM THE MACHINE.

FIG. 87—STOCK OF STANDARD TOOLS IN A RAILWAY GENERAL STORE. SEE FIG. 69 FOR THE STANDARD SHAPES. THE ACTIVE INTEREST AND WORK OF AN EFFICIENT STORE DEPARTMENT IS AN ESSENTIAL TO THE ATTAINMENT OF THE FULL BENEFITS AND ECONOMIES IN THE USE OF STANDARD MATERIAL. THE STOREHOUSE SYSTEM, OF WHICH THIS PICTURE ILLUSTRATES SOME OF THE CHARACTERISTIC SHELVING, IS THE RESULT OF THE WORK OF ONE OF THE MOST AGGRESSIVE AND UP-TO-DATE STOREKEEPERS IN THE COUNTRY, AND ONE WHO HAS SAVED THOUSANDS OF DOLLARS YEARLY BY HIS METHOD OF HANDLING MATERIALS AND SUPPLIES, COMMERCIALLY AND ECONOMICALLY, AND OF ELIMINATING WASTEFUL PRACTICES.

of machine equipment. What I wish at this point further to develop, however, is, that such fitness can be secured with very great economy, in regard to fixed or overcharges, by intelligent and systematic re-design, by partial reconstruction, and by increasing the speed and capacity of the old tool equipment. It may be confidently asserted that there is scarcely a railroad in the country which does not possess nearly twice the number of machine tools that it actually needs to keep up its power and rolling equipment, provided these tools were properly "balanced" with reference to one shop and another, and used with the object of gettng the utmost from their investments.

Economy in Reconstruction of Old Machinery.

If this reformation of tool equipment is followed up by some system of rewarding labor according to individual effort, or some other financial incentive toward time reduction in machining and other operations, full benefit from these improvements will speedily result.

IV. STANDARDIZATION OF THE SMALL-TOOL EQUIPMENT.

It needs no argument to point out that if the small hand tools used with air motors and otherwise in the erecting shop and on the bench, are reduced to a uniform standard throughout the shops of an entire railway system, economies in either the purchase or manufacture of these tools will result. This standardization should exist, from the drift pins and chisels to the type of screw or pipe wrench decided upon.

It will often happen that the foreman of one shop will order a grade of steel for his chisels more expensive than there is need for, or that a boiler-maker foreman at another point will select some special high-grade round steel from which to make his flue rollers. At another point, machinists' hammers will be forged on stock order instead of being obtained through requisition and purchasing agent, although the home-made hammer is not of as good quality nor shape, nor nearly so cheap in labor, as the purchased article. In this connection it should be noted, however, that it would be best for the railroad to "handle" its own hammers, as the usual handle furnished by the manufacturer is not satisfactory.

Economy of Standardizing Small Tools.

These small items here mentioned are not imaginary ones, but cases from actual experience, each representing in the aggregate thousands of dollars for the railroad in question.

Most railroads at the present day have standardized their beading tools, and furnish from their central tool-rooms standard gauges by

which to try these for each shop. There are other boiler-makers' tools which should be similarly standardized, such as flue rollers for use with the air motor, which should always be self-feeding; an illustration of these has been shown in a previous article. These when standardized can be more economically manufactured in the central tool-room than purchased from the railway-supply concerns, and can also be more promptly furnished on requisition. Another advantage of standardizing these tools is that all the rollers will be of uniform size for each type of flue rollers, and the other parts of the tool will be interchangeable and supplies can be more economically carried in stock and renewals made than is usually the case where each shop has an agglomeration of the various types of rollers, purchased now from this manufacturer, now from that, many of them having the small rollers missing, necessitating special sizes to be turned to fit them. The economies in the cost price of these tools here cited do not take account of the much more serious wastes in the time of the men learning to use the different types of rollers and attempting to get satisfactory results from them. It is needless to point out that where a standard flue roller is adopted, a man once learning its use will always be able to handle it to the best advantage, even though he be transferred from one shop to another shop[1].

Standard Boiler-makers' Tools.

Centralized Manufacture of Standard Flue Rollers.

Another boiler tool that should be standardized is the set of taper plug taps. These should be made of standard diameter and taper, and should be tried out by standard-thread gauge at each shop at least once a month. The economy in having such plug taps standard lies not so much in the economy of the initial cost of the tools themselves as in the lessened cost of finished plugs, manufactured at the central shops in large quantities and sent to outlying points on requisition. Similarly, staybolt taps should be standardized and inspected, enabling staybolts to be centralized in their manufacture, produced economically, and furnished to the outlying points as required instead of having each small shop turn up and thread its own staybolts as the requirements of some particular engine demand.

Economies in Standardizing Taper Plug Taps.

Chisels and beading tools lead to the mention of the special types of tools used with an air hammer. The shanks of these tools should be standardized and the hammer bushed to carry the standard shank.

Standard Hand and Air Hammer Tools.

[1] See illustration of standard flue rollers, p. 91.

Furthermore, a standard design of: (1) flat chisel; (2) cape chisel; (3) round-nose chisel; (4) diamond-point chisel; (5) ripping tool; (6) caulking tool, and one or two others, should be adopted.

Standardization Applicable to all Small Tools.

The steps that have been here briefly indicated for the boiler tools are equally applicable to the erecting shop and bench tools, to the tools of sheet-iron workers, tin- and copper-smiths, and others.

The economies resulting in a general standardization of small tools over an entire railway will be considerable. It is worth while to pursue a systematic policy of collecting up all the spare tool equipment, and this will necessitate the frequent inspection of all lockers to thin out the accumulations of pet tools carefully hoarded by selfish workmen.

The possibilities of saving in the wise selection and care of small tools used on the machines are, however, quite as great as in the case of hand tools, and probably play a more important part in effecting economical manufacture. The advantages of the new high-speed alloy steels over the old carbon and self-hardening varieties have been thoroughly explained within the last two years, and there is no need to dwell at length upon the changes that these new steel tools have wrought and are working in the machine shop of today and in the construction of the machines themselves. But the question was always raised as to whether these steels should entirely displace the older steels in the shops, as to the quantity of new steels it would be economy to purchase, and as to the method of disposition and custody of these expensive steels—and tools made from them—when purchased.

From an extensive experience with just this problem from the very first introduction of steels into railroad work, I should advocate with few exceptions that all the tools used on the machines—that is, on the planers, lathes, slotters and shapers, vertical and horizontal boring mills—should be replaced with high-speed tools. The permissible exceptions would be some of the finishing tools, and possibly tools used on soft brass or on babbitt. This wholesale condemnation of the existing tool equipment is advisable both on account of its permitting a general speeding up of the machine tools and because of its securing standardization of size, shape, cutting edges, rakes, method of grinding, etc., of the machine tools, instead of leaving these important matters to the individual preference of the men. A few of the tools so displaced in one shop are shown in the article of this series in the preceding month. The usual practice in many railroad shops is for the mechanic to select

Shop to be Completely Equipped with High-Speed Tools.

the size bar he wishes a tool made from, and to stand by the blacksmith tool fire and supervise the hammering out and shaping of the tool to suit his individual taste. This practice results in many tools being far below the efficiency that should obtain, and is a source of great waste of the workman's time. Both of these disadvantages are overcome by the policy of centralized manufacture, from standard design, of all tools of this kind. In a shop of large size it is advisable even to carry this specialization of work on these tools to the regrinding in the tool-room, instead of permitting the men to regrind them themselves.

Centralized Manufacture of Tools.

The following illustration shows a large rack in a central storehouse for holding a complete stock of standard punches, machine tools, reamers, taps, etc., manufactured in a central tool-room. These supplies are shipped to outside points on requisition.

Ideal Tool Rack for Central Store.

If with this system of centralized manufacture there is combined a supervision system whereby each local tool-room foreman keeps a list of each and every high-speed tool issued and checks the same over in the shop at least once a month, the greatest efficiency in tools will result, for the kind of tools best adapted for the work will be in service, and the smallest number for the output will be in use. The records will further serve to regulate the apportionment of tools, and by calling attention to certain needs of the department in the way of tool equipment, should prevent a haphazard and wasteful expenditure.[1]

Supervision of Tools and Records.

Another way in which investment in high-speed steel can be kept at a low figure, and costs in the manufacture of tools be reduced, is by means of a special design of chuck for use with the high-speed steel flat drill. It has been shown by test and in practical work that a flat drill when properly shaped and ground is as efficient for drilling cast iron as a twist drill. Inasmuch as the cost of manufacturing a flat drill from plain bar steel is much less than that of machining a twist drill, and as a twist drill requires more material for the same size than a flat drill, it will be readily seen that in providing these tools over an entire railway system considerable savings are possible.

High-Speed Flat Drill and Chuck.

The accompanying illustration shows the chuck and its construction. In the first elements on the left are shown a flat drill with the pin that holds it in the Morse taper shank which stands alongside of

[1] See article, "Care and Control of the Small-Tool Equipment in the Shop," by R. Emerson, in Engineering Magazine, February, 1905.

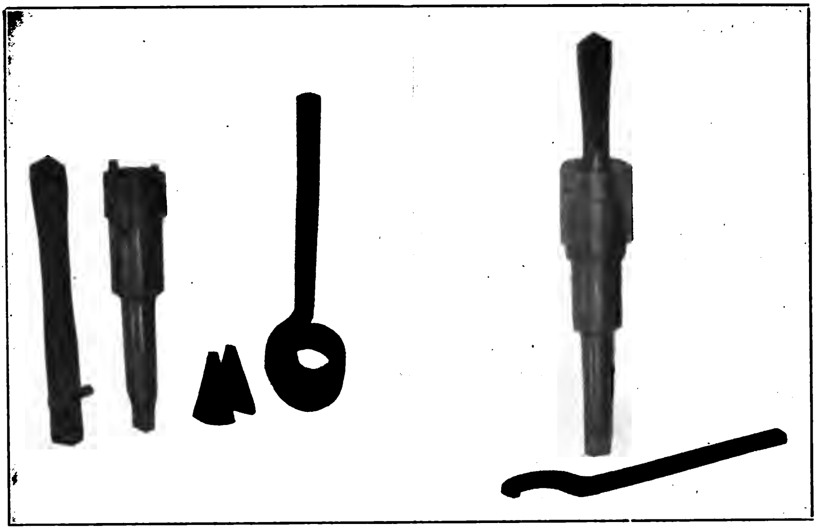


FIG. 88—HIGH-SPEED FLAT DRILL, DRILL CHUCK AND PARTS, WITH ASSEMBLED "PHANTOM" VIEW, SHOWING THE DRILL IN THE CHUCK READY FOR SERVICE. THIS DRILL IS MADE FROM PLAIN FLAT BAR TOOL-STEEL, IS MUCH CHEAPER TO MANUFACTURE THAN THE TWIST DRILL, AND IS NEARLY AS EFFICIENT AT HIGH SPEEDS.

FIG. 89—GROUP OF STANDARD FLAT DRILL CHUCKS, MANUFACTURED IN CENTRAL TOOL-ROOM FOR DISTRIBUTION TO OUTSIDE SHOPS.

FIG. 90—CASE FOR HOLDING STANDARD TEMPLATES, GAUGES, COLLARS, PLUGS, ETC., IN CENTRAL TOOL-ROOM. THESE GAUGES REQUIRE CAREFUL HANDLING IN ORDER TO PRESERVE THEIR ACCURACY.

FIG. 91—TOOL RACK FOR HOLDING SMALL TOOLS IN SHOP TOOL-ROOM. THE RACK IS MADE CHEAPLY, BUT IS CONVENIENT FOR USE AND ECONOMICAL OF SPACE. THE SHELVES ARE INTERCHANGEABLE. NOTE THE LOWER RACK FOR FILING FLAT TEMPLATES IN VERTICAL POSITION. DESIGNED BY SHOP SPECIALIST.

it. Next are shown two detached jaws which hold the flat drill in place, next the collar or coupling bored out taper, to be screwed down in place over them with the spanner wrench, also shown. The one on the right shows a phantom picture of the drill in place in the chuck with the collar down.

Following are shown a number of these chucks as they are received finished from the tool-room ready for shipment by the stores department to outlying points on the road. Each minor shop or roundhouse is supplied with one or more of these chucks for use in the drill press, and a set of such high-speed flat drills as may be needed.

Functions of the Tool-Room.—Greater progress has been made by railroads all over the United States in the last four years in building new shops and equipment with up-to-date machinery, such as motor-driven machine tools, electric cranes, power plants, etc., than had been made in the previous twenty-five years.

Scope of Tool-Room.

But there is one department which has been overlooked, and is not up to the standard of a thoroughly modern manufacturing concern, and that is the tool-room. By "tool-room" is meant that part of the railroad machine shop in which all special reamers, taps, cutters, jigs, templates, and measuring appliances, etc., are made, stored, and preserved in a satisfactory working condition. In addition to these functions, the average railroad-shop tool-room takes care of all repair work, such as the repairing of all shop machinery, pile-drivers, steam shovels, snow plows, automobiles, computing and adding machines, electric and otherwise complicated locks, time-locks, penknives belonging to officials, etc., etc. In fact, the tool-room is a place where all odd jobs are taken. But this extra work can only be done at the expense of the regular tool-manufacturing. All of these odd jobs should come under a separate department, devoted to such repair work.

In a broad sense it has been said that the prime function of the tool-room is to act in the capacity of an arsenal to provide the management with the necessary weapons to wage war upon excessive cost; the word "excessive" is here used to indicate any excess of cost beyond that minimum at which it is possible to produce the article to be manufactured. Now and then a master mechanic tells us he has built and repaired engines without having any tool-room connected with the shop. In days gone by, successful battles were fought with clubs, bows and arrows; but what chances would these same armies stand with a modern army equipped with modern weapons?

An aim of every superintendent of motive power is to obtain the most extensive output possible at the lowest cost, and the tool-room is perhaps the most important factor in bringing around such a result.

Tool-Room Organization.

The location of the manufacturing tool-room should be separate from the tool-storing and distributing department. The latter department should be located in the central part of the shop, to be within easy access of all workmen requiring tools. The tool-manufacturing part should manufacture for the entire railway system, thereby insuring an exact standard for all tools. Most railroads have the machine foreman run the tool-room in connection with his own department; but this is a very grievous mistake, for the work requires a competent tool man, one who has had extensive experience in tool work and who has made this branch a special study; a man of this calibre cannot be had for 35 cents or 40 cents per hour.

To operate a tool-room satisfactorily, at least one draughtsman should be associated with it to work in conjunction with the general tool-room foreman. He should keep a record of all tools made, and should control in a large measure the locating of tools, so that similar tools, either actually in stock or anticipated, may be grouped and numbered according to size, much after the manner of indexing and classifying patterns in well-regulated shops.

Standard Punches and Dies.

In a previous section we dealt with standardized tools. In the illustration of punches on page 147, it will be observed that the non-standardized punches are grouped at the left in black. These were only a few picked up in about fifteen minutes' hasty rummaging of a Sunday morning in one shop. It will be noted that each is of a different length, and of a different mode of fastening at the base; moreover, that the diameters of the bases vary. The condition all over the whole railroad and the wide variety in style of punches used, can be guessed from this one example. The punches which are lighter in color are the standard ones. On the right is shown a stock which is made of such lengths and styles as will fit it to the particular machines. This stock replaces the stock with which the machine is supplied by the manufacturer, and serves the purpose of enabling punches of standard length or height to be used in all cases. It will be noted that the upper end is threaded to engage the hexagon coupling shown beside the stock. These couplings are all alike, and consequently the bases of all punches can be made alike. In order to save material in making small punches,

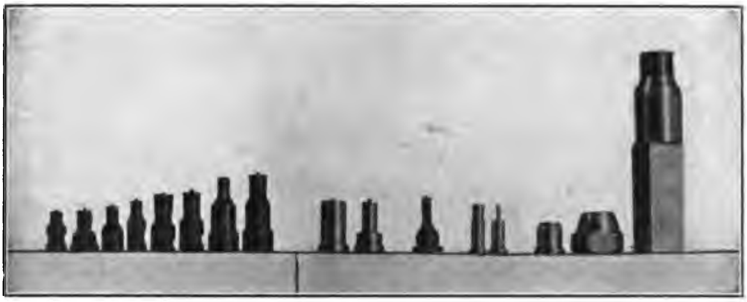


FIG. 92—GROUPS OF NON-STANDARD AND STANDARDIZED PUNCHES AND STOCK. THE MANY TYPES OF PUNCHES SHOWN ON THE LEFT WERE REPLACED BY STANDARD PUNCHES ADAPTED TO ALL PUNCHING PRESSES, BY THE USE OF THE STANDARD STOCK AND COUPLING SHOWN ON THE EXTREME RIGHT.

FIG. 93—STANDARD PUNCHES, STOCKS, COUPLINGS AND BUSHINGS, AS MANUFACTURED IN QUANTITY AND BEFORE SORTING FOR DISTRIBUTION FROM CENTRAL TOOL-ROOM TO ALL OUTLYING SHOPS, THROUGH THE INTERMEDIARY OF THE GENERAL STORE.

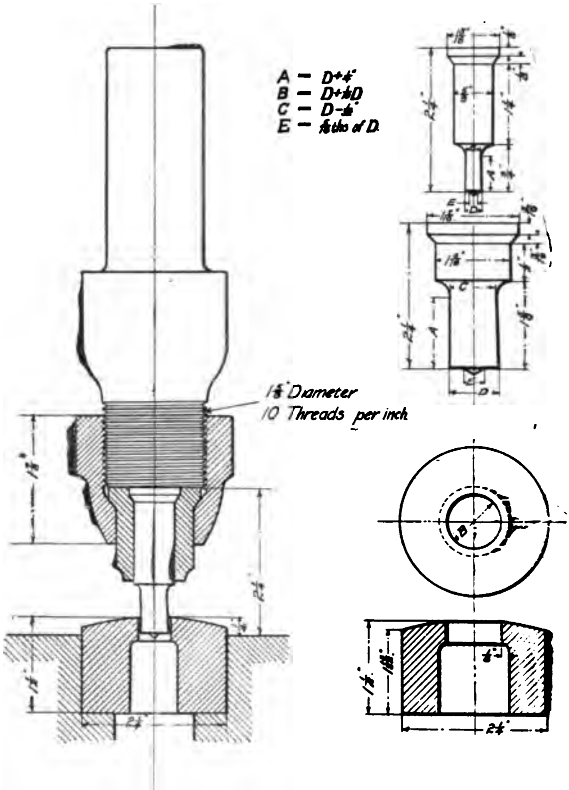


FIG. 94—GENERAL ELEVATION AND SECTION OF STANDARD STOCKS, PUNCHES AND DIES.

instead of turning these from a large bar they are turned from a small bar, and a bushing is shown also in the illustration, as used to bring the bases to standard size. The material thus saved comes to a considerable amount on a large railroad.

Economical Limits of Manufacture in Tool-Room.—The problem of reducing time (cost) in the manufacture, repair, and assembling of locomotive parts is so intimately associated with the character of the tools and devices used in the different operations, that it is not logical to separate these two elements, the means employed to get work out and the obtaining of maximum efficiency in the use of these means. For this reason I have always considered the design of tools and jigs of paramount importance, as the method determines in advance the time limit for the job; while the matter of keeping the men near this minimum is a matter of discipline of men rather than of intelligent direction of work.

Relation between Design of Tools and Cost of Production.

For this reason, also, a railroad shop cannot without direct loss avoid manufacturing a considerable proportion of tools applicable only to the peculiar design of certain locomotive parts. Even if these tools could be purchased from the manufacturer for less than their cost in the local shop, it would be a doubtful economy to order them, as the making of detail drawings and specifications and the loss resulting in work from delay in putting new methods into effect, as well as the disadvantage of not having supervision and inspection of the tools during their manufacture, would more than counterbalance the reduced price. But as a matter of fact, tool-manufacturing concerns are no better equipped for handling special designs of tools than a well-planned railroad shop, the ability to turn out such articles cheaply depending upon the experience of the men in charge of the work, and not upon the machines, which are much the same under both conditions. If, however, the tools are not produced under intelligent direction, it will not pay for a railroad shop to undertake their manufacture.

Shop Manufacture of Special Tools.

A good illustration both of the economy secured by thought and experience in the initiation of quick and accurate methods in locomotive work, and of the wastefulness in having tool manufacture undertaken by persons unfamiliar with the subject, is the following.

The idea was to standardize work on crosshead fits, everything to gauge instead of continuing the old hand fit. On compound engines,

the piston rod works loose in the crosshead, and wears the hole oblong.

Standard Crosshead and Piston Reamers.

To true out these holes the crosshead has hitherto been put in a machine and been bored out. With the reamer that was made for this purpose, it was impossible to ream out these steel crossheads, as the reamer was not properly designed for this class of work, the flues being straight, and gouging into the work, thereby stalling the machine and breaking off the end of the shank. Therefore, the truing up of these holes was done in a boring mill and took about six hours. More often, though, the holes were let go, not being trued up, and piston rods were fitted to them in this state.

Necessarily the life of a rod so fitted would be only one-half the life of one that had been fitted up to a hole that was properly trued. With the present standardized reamers, the man on the boring mill reams out two holes per hour. On one hundred and twenty compound engines going through a main shop in a year, four holes being reamed

Economy of Standard Reamers.

on each engine, there is in crossheads, in reaming out crosshead pinholes, in piston heads, a saving in all of over $1,700. Owing to cruder methods, the same work is even more expensive when done at other points than at the main shops. These figures do not take account of the losses in life of piston rods.

The next illustration shows the evolution of the crosshead and piston-rod reamer from a rough contrivance of wood and brass to a

Evolution of Crosshead Reamer.

modern one made of high-grade steel, with spiral flutes, in two sections, hollow for the purpose of even cooling in the tempering process and with soft-steel arbor. The crosshead reamer is extensively described in the "Economical Limits of Manufacture in Tool-Rooms."

The working out of the details of this standardization was left to the mechanical engineer and the general tool foreman. It was determined in advance what shops were to be supplied with the reamers,

Methods of Standardizing Crosshead Reamer.

and eight extra blanks were provided in case any reamers were spoiled in making, or additional reamers required. A first-rate quality of tool steel was ordered so as to prolong the life of cutting edges and keep down the maintenance and high item of grinding a reamer of this character.

At the time the drawing was made, it was proposed to state the material and details of design of reamers and arbors; but it was finally decided to leave these matters to the judgment of the tool-room foreman.

FIG. 95—VIEW ILLUSTRATING THE EVOLUTION OF THE CROSSHEAD REAMER.

FIG. 96—"PHANTOM" VIEW OF CROSSHEAD REAMER, SHOWING HOLLOW REAMER, AND ARBOR OF PLAIN MACHINERY STEEL.

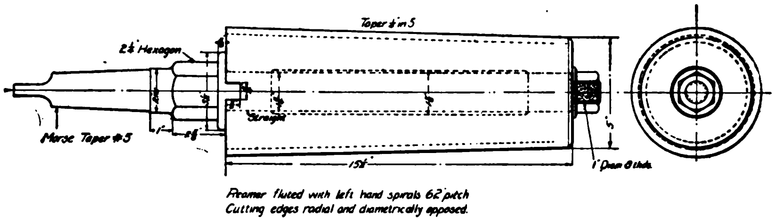


Fig. 97—General elevation of standard crosshead reamer and arbor.

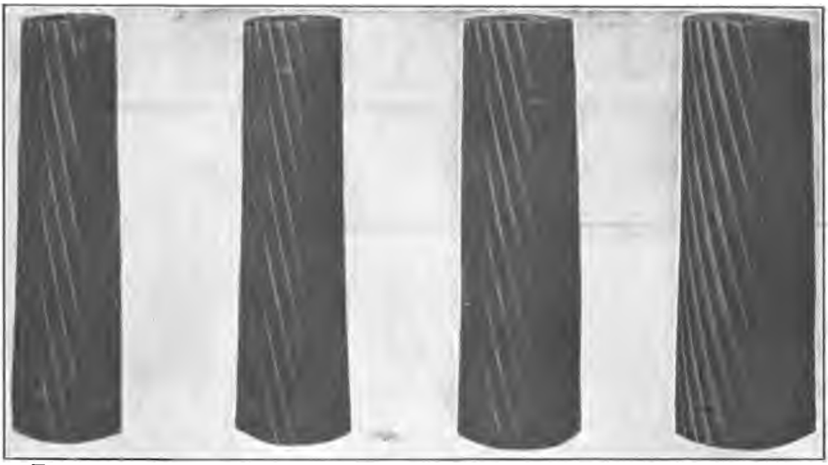


Fig. 98—Group of four standard crosshead reamers, completely fulfilling the requirements in crosshead and piston fits of several large classes of locomotives.

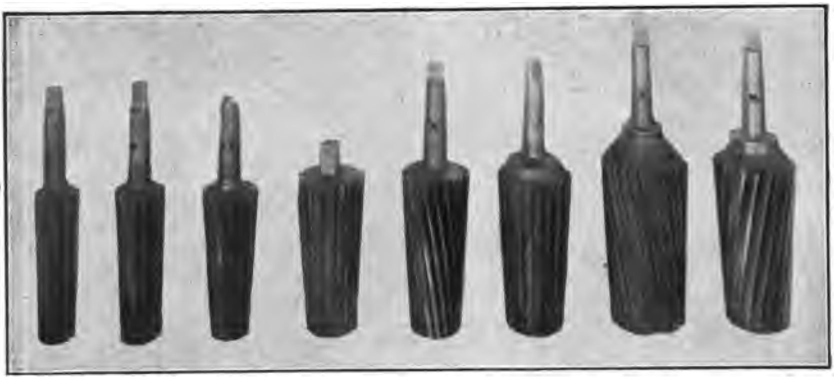
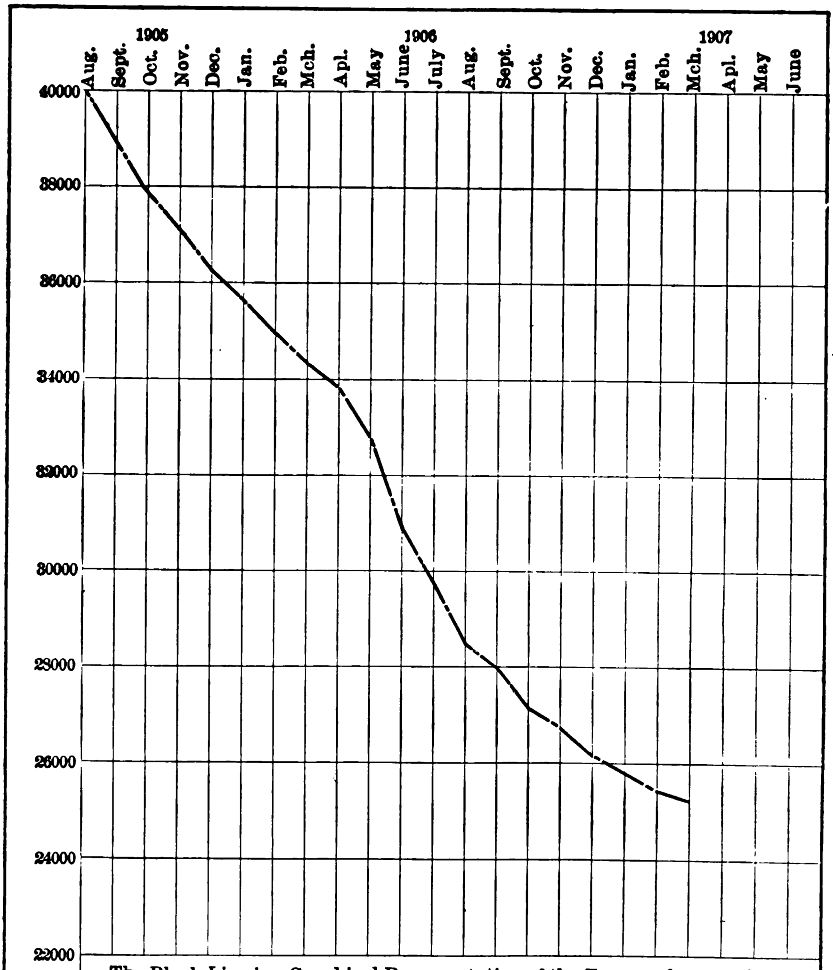


FIG. 99—THE KIND OF REAMERS, WITHOUT STANDARDS AS TO SIZE, TAPER, LENGTH, OR MANNER OF CONSTRUCTION, AND DESIGN, THAT RESULTED IN ONE SHOP FROM THE WORKING OUT OF THE IDEAS OF THE INDIVIDUAL FOREMAN. THESE REAMERS ARE THEMSELVES NOT ONLY SEVERALLY MORE EXPENSIVE TO CONSTRUCT THAN THE STANDARD ONES, AND LESS EFFICIENT IN OPERATION, BUT THEY ALSO MAKE THE WORK ON THE LOCOMOTIVES VERY COSTLY IN REPAIRS AND REPLACEMENTS.



The Black Line is a Graphical Representation of the Expense for certain Shop Maintenance costs, plotted by Months. Each Point on the Line or "Graph" is the Average Expenditure for each month of the twelve months preceding.

A REDUCTION OF $200,000 PER YEAR ON AN ACCOUNT THAT FORMERLY RAN HALF A MILLION DOLLARS YEARLY. THIS ACCOUNT HAS BEEN INCREASING AT THE RATE OF 15 PER CENT PER YEAR FOR THE PAST EIGHT YEARS, UNTIL SEPTEMBER, 1904, WHEN THE BETTERMENT WORK WAS STARTED. NOTWITHSTANDING MORE BUSINESS, THIS ACCOUNT NOW SHOWS AN AVERAGE REDUCTION OF OVER $200,000 PER YEAR IN ADDITION TO BETTER TOOLS AND GREATER EFFICIENCY IN TOOL SERVICE. THIS WAS BROUGHT ABOUT THROUGH STANDARDIZATION AND CENTRALIZED MANUFACTURE OF ALL SHOP TOOLS, ALSO BY CLOSER SUPERVISION AT OUTSIDE SHOPS. IT WILL BE NOTED THE ACCOUNT IS STILL BEING REDUCED.

The labor costs were made as low as they proved by applying commercial methods in the manufacture, doing each operation on all the blanks at once. From the time the material arrived to the date the reamers were shipped to their respective destinations was three months, not interfering with regular tool-room work. However, as the general tool foreman left the tool-room shortly after the work was started, he could not continue to give the matter his personal attention. In consequence, upon his return he found that in applying arbors, six of which had already been made of machinery steel, the acting foreman over tool-room work had already used a steel at 46 cents a pound for these arbors instead of machinery steel at 3 cents, entailing the needless expenditure of $240. The more expensive steel is not so fit for the purpose used, being more brittle. It should not be possible for mistakes of this kind to occur, and some method should be devised for checking up tool work, so that it may be properly directed. Unless specific instructions are issued covering all details of importance, too much leeway is left for making individual variations in the work.

Many benefits would accrue from having an efficient inspection system, including statements of labor and material on each order for all new work manufactured in shops. The tool-room would be an excellent place to begin this inspection system, if it is proposed to carry on the manufacture of tools there on an extensive scale. In this way it is possible to oversee all this work, and by comparison with requisitions for purchase of new tools, determine just what tools to purchase and what to make in the shops. With this would be included the checking over of all store orders for new tools, and also the gathering of data of costs of making various tools in the shops, and the corresponding manufacturers' prices.

V. ERECTING-SHOP ECONOMIES.

High-speed steels and re-designed machine tools have worked great improvements in machine-shop production. Have all the other departments been improved to keep pace with the machine shop? The blacksmith shop with its Bradley hammers, bolt-headers and bulldozers, and accompanying oil furnaces, has made rapid strides; and the boiler shop with its hydraulic forming press and riveter, gasoline and oil heaters, and annealing furnace, together with all the pneumatic tools, is well in line; but how about the erecting shop? Here we find little or nothing has been or is being done. True, there is now and then a cylinder boring

Progress Conditions in Erecting Shop.

bar or probably a rotary planer for valve seats, and perhaps a few antiquated air motors; but close scrutiny reveals the fact that the tools in the erecting shop are sadly in need of attention, for the reason, perhaps, that it has never been thought necessary to give to the men those individual tools which diminish the manual labor and consequently decrease the number of hours and the cost of production.

Economy of Standard Ball-Joint Reamers.

One great hindrance in erecting shops is a lack of standards. An instance is that of ball-joints on dry and steam pipes. With a standard radius for these joints, and forms to suit, all steam-pipe and dry-pipe joints could be finished without the annoying delay of making a sheet-iron template for each joint, and steam-pipe rings could be kept in stock with the ball-joint finished, requiring only a few minutes' work to cut it off for height when one is wanted. The laborious job of grinding a dry pipe into the flue sheet could be eliminated by the use of forms, and the time reduced from eight or ten hours to one and one-half or two.[1] The same is partially true of the standpipe and throttle joints: by having all joints of standard radius, an interchange of parts would be effected in a short time in many cases, avoiding serious delays in engines leaving the shop.

Standard Washout Plugs.

Washout plugs form another case where a standard taper is indispensable, as by bringing all plugs to that standard, interchangeability and greater safety as regards the danger of blowing out are secured.

Standard Taper for Engine Bolts.

A standard taper for all engine bolts could be easily arranged, and by maintaining it a great saving of labor could be effected. With all reamers of standard taper, bolts could be turned and fitted to blocks at the lathe and kept in stock finished. The erecting men would then be enabled to have a bolt on hand when they are reaming holes, obviating the necessity for the machine men to go into the erecting shop to caliper the hole, and to return again to put the bolt into the hole and file it if necessary. The size and length of all boiler studs could be taken and a number given to each size, and they could be kept in stock and handled as easily as spring cotters. It would first be necessary to check over all the boiler taps and have them conform to a given standard. The same standardizing could be carried out in all cab brass work and boiler mountings, cylinder cocks, boiler checks, and relief valves, so that all

[1] See pp. 89, 90 for illustrations of standard ball-joint reamers.

FIG. 100—SLING DEVISED FOR THE QUICK AND SAFE PICKING UP AND CARRYING OF DRIVING-BOXES BY CRANE FROM ONE PART OF A SHOP TO ANOTHER. THESE BOXES DO NOT REQUIRE A SKILLED MAN TO ADJUST A ROPE SLING FOR THE SAFE CARRIAGE FOR EACH INDIVIDUAL BOX, AND THEY WILL NOT DROP ON THE HEADS OF UNSUSPECTING WORKMEN AS THEY PASS BY. THE BOXES ADJUST THEMSELVES IN A NEAT PILE ON BEING LOWERED TO THE FLOOR, AND THE SLING IS DISENGAGED INSTANTLY. DEVISED BY AN AGGRESSIVE AND INTERESTED MACHINE SHOP FOREMAN.

FIG. 101—MOTION PICTURES TAKEN OF RAILROAD AND SHOP OPERATIONS FOR THE INSTRUCTION AND ENTERTAINMENT OF THE MEN, IN SERIES OF FREE LECTURES GIVEN, DESCRIBING MODERN SHOP METHODS, AND ILLUSTRATING THE ADVANTAGES TO THE MEN OF THE INTENSIVE OUTPUT LABOR REWARD, IN ORDER TO ENLIST THEIR INTEREST AND COÖPERATION IN THE PROMOTION OF THESE EFFICIENT METHODS.

joints would be of the same radius, and valves of the same size could be interchanged.

Anyone with knowledge of work in the erecting shop can readily see how much it would be of advantage if all spring rigging and driver-brake pins were standardized, numbered, and kept in stock. Why should a machinist earning 33 cents per hour be allowed to spend from twelve to fifteen hours truing up the journals on a tumbling-shaft, when a machine can be made to do the work far better in one and one-half hours? Or why should a man be compelled to ream holes by hand in close quarters where an air motor could not be used directly when a geared device could be made to permit the use of a motor?

Standard Brake Rigging Pins.

A few devices which aid erecting work are: A bar and mandrel for hanging guides instead of the old method of using a line; a hydraulic piston extractor; an air gun or a cannon for stubborn frame bolts in place of a sledge and a lot of muscle; a suitable air motor for a valve-setting machine. Why have four men pull in a cylinder bushing with a big wrench when one man can do it with an air motor and the gear of a boring-bar? Again, if a pneumatic hammer is essential to a boiler-maker chipping and caulking a seam, why is it not as essential to a machinist when chipping a cylinder saddle or filleting a frame for shoes and wedges?

Special Erecting Work Devices.

Another need is for a more careful watch over air tools to see that they are economical as to the use of air or are discarded when unfit for use. In the condition in which they are kept there are many occasions where it is more economical to drill by hand than to use the air motors. A sufficient quantity of air drills and hammers is the first requisite of an erecting shop, and it is important that they be kept in the best working condition.[1]

Supervision of Air Tools.

Another feature is an equipment of hand tools. I have seen a machinist spend forty-five minutes tapping a hole in a boiler sheet with a worn-out tap when it could be done in five minutes with a good tap, and I have seen reamers ruined by having the wrench not fit properly and turn the corners of the square end. I have seen, too, seven hours spent in drilling out a bolt when two would have sufficed with a proper equipment of twist drills and sockets, and four hours spent reaming a hole where one-fourth the time was spent waiting for another man to get through with a reamer.

Importance of Good Tools.

Following are some devices needed in erecting shops: Stand for

[1] See article, "Pneumatic Power in the Machine Shop," by R. Emerson, Engineering Magazine, February, 1906.

setting stack saddle from nozzle base; device for quartering wheels; air device for use when reaming holes vertically; numbered templates for blacksmith and erecting shops, for equalizers and driver brake hangers; jigs for drilling piston glands, back cylinder heads, steam chests and glands, cylinder frames, etc., to afford interchangeability; jigs for compound crossheads to allow guides to be hung standard.

Devices Needed in Erecting Shops.

Miscellaneous Economies.—We have followed through the conception of standardized engine parts and its practical application in manufacturing methods in shops, together with the methods of handling the shop work as effected with the plan of standardized repairs. There are numerous minor advantages that may be summarized here, incidental to a thorough working out of good system. We might thus enumerate the branches to which intelligent study of conditions and application of systems should be applied:

Methods for Standardizing Repairs.

1. The routing of work through the shops.
2. The handling of shop orders.
3. The making, providing, and using of standard blue-prints.
4. The establishment of shop sub-stores.
5. The standardization of air-tool equipment.
6. The supervision by a single expert of power plants and appurtenances, steam, electric, air.
7. The classification under individual foremen and by whole shops of the pay-roll, with an analysis of the same.
8. The introduction of a system of reward according to individual effort.
9. The offering of bonuses for saving material.
10. The proper consideration of overcharges, or "surcharges," in comparing shop costs with manufacturers' prices.

Let us take up further examination of these points seriatim:

1. There is often great confusion and unnecessary delay in handling any particular job, or series of jobs, through the different departments of a shop, or even in one department, and there is a general lack of system in placing the work in order of its importance. Two very simple methods of handling and routing work are: First, to have a board subdivided according to the shops and the individual machines, gangs, smith fires, benches, or men, in the various departments, with tags or pegs representing a particular part having work done on it. From this

Routing Work Through Shops.

board a daily sheet may be drawn showing the progress each day through each department, and as the work on each locomotive or shop order is scheduled according to the requirements of the operating department or the store department, the detail elements of the whole job in each case can be provided for like the operation of a regular train schedule or time table. Second, the articles themselves may be provided with tags indicating whence and whither, with days and hours for delivery to and by each department. Red or green tags might indicate rush jobs; but these tags should be under the hand of the superintendent of shops and doled out by him for rush jobs only.[1]

Handling Shop Orders.

2. As the shopping of engines is dependent on the requirements of the operating department and traffic, so the urgency and amount of shop-order manufacturing depends on the requirements of the store department, in so far as that department foresees coming demands or has to fill requisitions from outlying points. The men in charge of shop-order work at the central shops should therefore act in thorough accord with the store department, studying its needs, fulfilling its requirements systematically and promptly. The store department, on the other hand, should furnish its information in specific form, and should insist on the requisitions bearing all the necessary information before they leave the division storekeeper's hands. Shop orders, or store-order work, should be confined to the central shops and practically none be permitted at any outlying point, even though in some instances such manufacture might be done just as cheaply at the small shops as centrally. The reason for this is that there is apt to be a lack of uniformity of standards.

Standard Drawings and Blueprints.

3. At the time when a railroad decides to standardize its engines it will also be well for it to systematize its mechanical engineer's office thoroughly. The tracings should be reduced to a few standard sizes, three or four sized in the relation of multiples being sufficient. As it is usual to have margins and a regular form of title for these tracings, it will be advantageous to have the tracing-cloth cut up into trimmed sheets and printed with the marginal lines and such other indications as appear on each and every drawing. This will save the draughtsman's time in unrolling and cutting off the tracing-cloth, will save waste in cloth itself if the standard sizes are made with reference to commercial

[1] See article, "Dispatching Board for Engine Repairs," by C. J. Morrison, in American Engineer and Railroad Journal, April, 1907.

width of drawing-cloth, and the printing will be found to be cheaper than the old hand method. On these tracing-sheets drawings of all standard parts will be made, and blueprints sent to the various shops, properly receipted for. These blueprints should preferably be mounted on a heavy pasteboard and shellacked over, and a standard blueprint rack supplied each shop in which to keep them, so that the drawing of any part may be quickly located. When this system of standard blueprints is first put into practice, one man should go from shop to shop seeing that it is properly installed, and that the blueprints are used by the men on the work and the work done in accordance with them. Thereafter, perhaps once a month, some one from the mechanical engineer's office should make a tour of the road both for inspection and to ascertain the local shop needs.

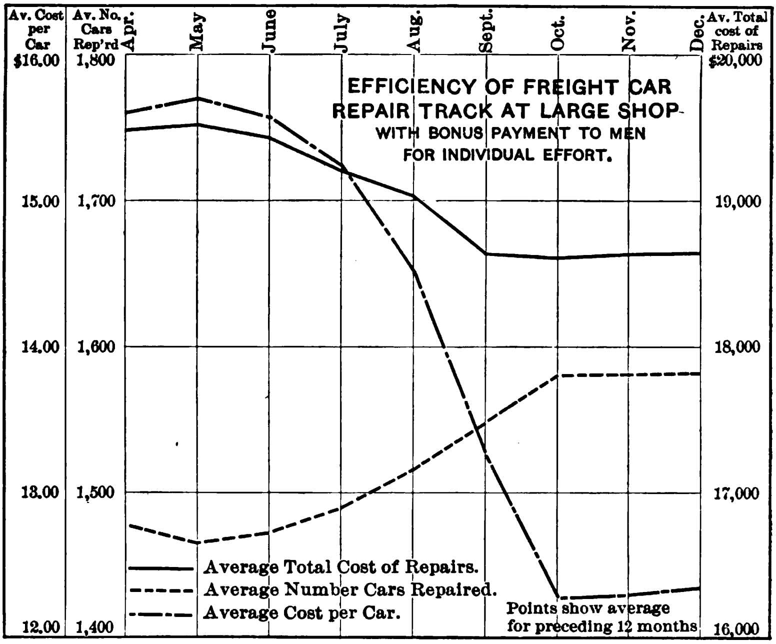
Material Sub-Stores in Shops.

4. These sub-stores save a good deal of time and bother. The material in them should be drawn on requisitions in just the same manner as from the general storehouse, and the requisitions turned over at the end of the day to the regular storekeeper. The foreman of the shop or department, or his clerk, will have charge of the sub-store, and an inventory should be taken at least once each week so as to keep the accounts for material straight. I should advocate such sub-stores for small and frequently used material only. The articles kept by these sub-stores should of course be carried in the stock account of the regular stores department.

Standardization of Air Tool Equipment.

5. The standardization of air-tool equipment has been covered in a series of two articles by Mr. R. Emerson, in the December, 1904, and February, 1905, issues of the *Engineering Magazine*. As explained in these articles, three or four types of air motors and air hammers are selected as standard, and such extra parts as may be required are either purchased from the manufacturer or made and kept in the central manufacturing tool-room. Any expensive air-tool repairs are made in this central tool-room, the motors or hammers being shipped in by express, duplicates having been sent out to the local shops to take their place immediately on notice of their being out of commission. In this way the small outlying points will always have a sufficiency of air-tool equipment in good order, and the repairs of this class of tools, on which the depreciation is very high, owing to the extremely hard service to which they are of necessity almost always subjected, will be reduced to a low figure.

In order to have pneumatic tools operate in a satisfactory manner,



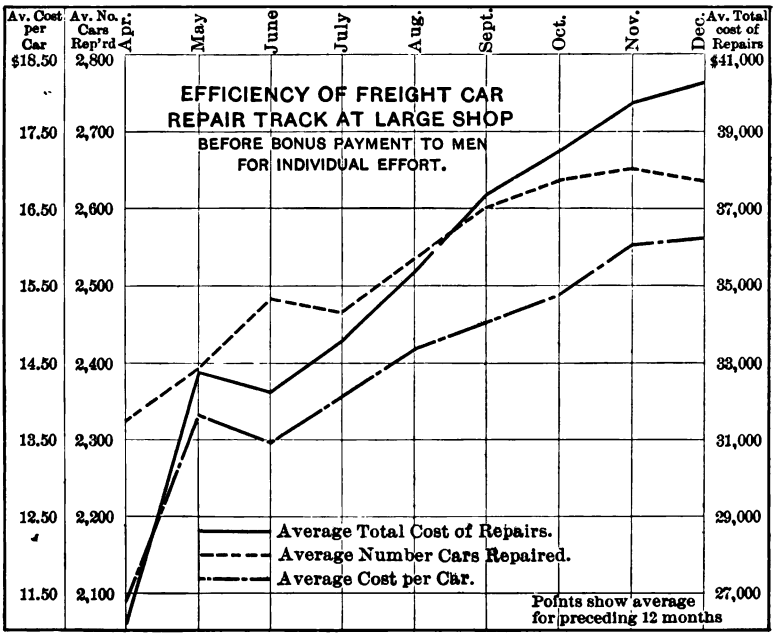
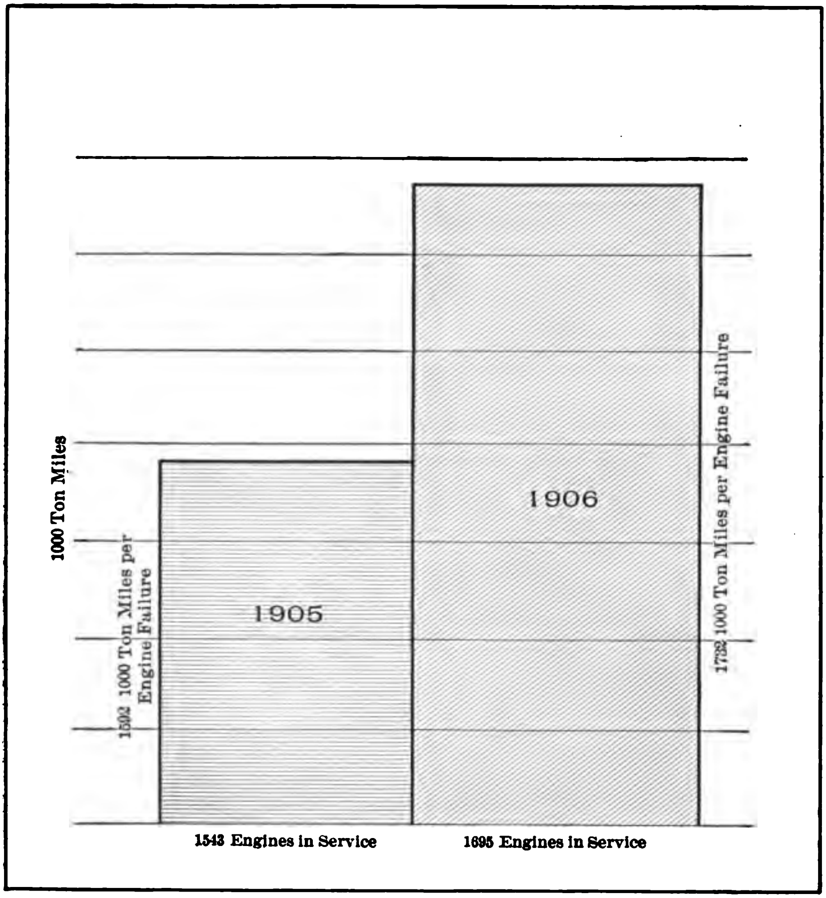


DIAGRAM SHOWING EFFICIENCIES OF FREIGHT CAR REPAIR TRACK BEFORE AND AFTER THE INTRODUCTION OF THE INDIVIDUAL EFFORT SYSTEM. THE ENTHUSIASTIC COÖPERATION OF THE CAR-FOREMEN WAS LARGELY RESPONSIBLE FOR THE HIGH EFFICIENCY OBTAINED AFTER THE ESTABLISHMENT OF THE INDIVIDUAL EFFORT SYSTEM.

TON MILES PER ENGINE FAILURE.

Comparison of Calendar Years 1905 and 1906.



FROM THE ABOVE GRAPH YOU WILL NOTE THAT IN 1905 THERE WERE 1592 1000-TON MILES HAULED PER ENGINE FAILURE, AND IN 1906 THERE WERE 1732 1000-TON MILES HAULED PER ENGINE FAILURE.

It may sometimes be urged that attention to efficiency in the maintenance of motive power will result in a greatly deteriorating condition of that power, with consequent loss of efficiency and an increase in failures of such power on the road. In order to ascertain whether such has been the case, the relation of engine failures to the volume of business handled (*i.e.*, gross ton mileage) has been ascertained and is plotted above. The tendency for improvement in this direction simultaneously with the elimination of waste in material and labor applied to engines is marked, and effectually offsets any argument that might be advanced to the contrary.

This improvement is not merely a temporary one, but it is likely to grow increasingly favorable owing to the method now being introduced, since the efficiency plan has been generally extended to all shops and roundhouses, of rewarding foremen for quality of output besides the efficiency of their men, and placing inspectors at each of the principal points, whose reward will depend upon the number and character of defects found.

a sufficient supply of dry air must be maintained at proper pressure, and to do this considerable care is required in locating the intakes of the air compressor, in operating the compressor, and in looking after the non-leakage of the pipes and the cooling of the air before it reaches the machines, with provision for tapping any entrained moisture. Similarly the electric lines, generators and motors need to be kept up. There is no more elusive yet real waste of power than occurs in a steam line, and these should be very thoroughly and frequently inspected in order to maintain them in efficient condition. Fuel economies in the boiler plant are likewise of importance and should receive a broad, comprehensive study.

Maintenance of Air and Electric Tools.

7. It is a very easy matter when once the pay-roll of any given shop or division of a railroad is classified according to service rendered, to check up this pay-roll daily according to the men who have worked, and determine just how much each portion of the work is costing. If this is done, actually but the work of a few minutes each day, it will be readily shown where it will pay to concentrate one's efforts in reducing this kind of expense, and a careful study of the conditions of the group that promises the largest reduction will reveal how such reduction can be effected. Under this kind of system, a reduction in shop operation expense of from 20 to 40 per cent can very easily be made within six months, at a cost of less than 10 per cent of the reduction itself. This kind of analysis applied to a $5,000,000 a year pay-roll for locomotive repairs will net a very handsome saving.

Classification of Work on Pay Rolls.

8. We shall touch a little later upon the subject of reward for individual effort, but it should be stated that whereas an expense reduction of 20 per cent or over can be attained by intelligent analysis and supervision without reduction in the output, an increased output with a simultaneous reduction in expense can be attained only by interesting the men financially in coöperating to this end.

Reward for Individual Effort.

Reward for Saving Material.

9. Similarly it is very difficult to attain any tangible results in the way of economical use of materials without offering some substantial form of reward for such care.

Surcharge on Shop Production.

10. Under "surcharge" I would refer to an article by Mr. C. J. Morrison, in the October 1906 issue of the *American Engineer and Railroad Journal,* and also the editor's comment in the same issue. Mr. Morrison explains the surcharge problem in detail, and gives the following list of the items

making up the surcharge account in a modern railway repair shop:

1. Rent:
    - A. Depreciation of buildings, 4 per cent per annum.
    - B. Interest on buildings, 4 per cent per annum.
    - C. Interest on land, 4 per cent per annum.
    - D. Repairs to buildings, material and labor.
    - E. Insurance.
    - F. Taxes.
2. Supervisory and Miscellaneous:
    - A. Superintendence and office.
    - B. Accounting.
    - C. Drawing room.
    - D. Spoiled work.
    - E. Laborers and watchmen.
3. Machinery:
    - A. Depreciation per annum, 4 per cent.
    - B. Interest per annum, 4 per cent.
    - C. Repairs (labor).
    - D. Repairs (material).
    - E. Replacing small tools.
    - F. High-speed and other steels.
    - G. Supplies.
4. Power, Heat, Light, Water, etc.:
    - A. Depreciation per annum, 4 per cent } On buildings.
    - B. Interest per annum, 4 per cent
    - C. Depreciation per annum, 10 per cent } On machinery.
    - D. Interest per annum, 4 per cent
    - E. Wages.
    - F. Fuel.
    - G. Repairs.
    - H. Supplies.
    - I. Lamps, coal delivery, etc.

These items, expressed as a percentage of the pay-roll, are found to average for a number of shops as follows:

	Locomotive Department.	*Car Department.*	*Total.*
Rent	11.5	8.1	10
Supervision and miscellaneous	13.8	12.0	13
Machinery	26.6	14.4	21
Power	8.1	3.5	6

It is common practice for railways in figuring costs of their manufactured products to consider only the cost of rough material and the actual cost of labor, adding from 10 to 15 per cent for supervision. When costs are figured in this way the prices obtained are low as compared with prices submitted by manufacturers, and railroad officials congratulate themselves upon a cheap output, while in reality if proper surcharges were considered they would be surprised at the reasonableness of some manufacturers' prices.

Individual Effort Rewarded.—After, and only after, a very clear idea of the manner in which shop betterment is going to be

carried on has been formed, and largely put into effect, should any tampering with the wage system of the men take place. The day or hour rate is objectionable because the man is paid for time, and not for output; therefore he seeks to put in as much time as possible with little respect to rendering a valuable equivalent for his wages, and the time he puts in is preferably over-time and over-pay. The straight piece-work system has been devised to overcome this, but has probably been the cause of greater dissatisfaction between employer and employee than even the inefficient day-rate system. Some form of premium or bonus not interfering with the man's regular daily wages should be devised, in order to have a smooth and satisfactory basis for all concerned. Moreover, the premium or bonus should not be for a certain piece of standard operation, but the individual reward should be determined for each individual set of conditions. For instance, for two men running two lathes side by side and each of them turning out the same piece of work, the time or extra money allowed to each man for the performance of this work should be governed by the conditions and capacities of each of the machines and by the rates of pay (presumably a measure of the efficiency) of each man. This, in brief, is the spirit of the system of rewarding labor according to individual effort; it is a system based upon close analysis of the demands, unit operations, and other conditions governing the performance of each piece of work, and it differs from the usual piece work or premium method in that guessing is eliminated, and actual observation by practical men, checked up by some one expert in figures, is substituted.[1]

Principles of Individual Effort System.

Benefits of Progressive Policy.

The general policy of the thorough carrying out of such a system of motive-power and shop betterment and systematization similar to that outlined in these papers, will have three real and great benefits:

Maintenance Expense Reduced.

First, that part of the operating expense known as repairs and renewals to locomotives and machinery will be very materially reduced, thus increasing the net earnings on the road.

Improved Conditions of Locomotives.

Second, the motive power will be kept up in better condition and kept out of earning service a shorter length of time, thus increasing the gross earnings and postponing the necessity for investment in additional power.

[1] See article, "Efficiency of the Worker and His Rate of Pay," by C. Hastings, in American Engineer and Railroad Journal, June, 1907.

Third, the shop output will develop a capability of considerable increase, taking care of in a large way and curtailing what would in the normal course of events be future shop extensions. These extensions for the most part would not be necessary; thus additional capital investment will be postponed. Furthermore, it will finally become practicable for the road to build locomotives in its central shops at a low figure.

Shop Output Increased.

These results can be guaranteed, provided the betterment system is thoroughly carried out; they can be guaranteed because they represent what has been done wholly or in part on roads in our experience.

EDUCATION AND PUBLICITY.—While machines and methods are the solid framework of production, unless the coöperation, interest and enthusiasm of the men can be obtained, the system is apt to be lifeless. So it may be said that an ability to get close to the men—to gain and hold their confidence—is even more important than method.

To gain the confidence of the man (not so easy in the constant strife and misunderstanding of the labor unions today), the introducer of these methods, or his representative in the shop, should be a practical and well-schooled mechanic himself, versed in the failings and ideas of the men of whom he has recently been one, and of a personality commanding, yet carrying with it an enthusiasm that is contagious. The rôle of such a man is to get the drift of the attitude of the individuals in the shop, to be able to recognize the leading spirits, and to enlist their active assistance in the work. This is the more requisite if any system of piece work or reward according to individual effort is being introduced along with the improved methods.

Necessity for Confidence of Men.

In dealing with the men, complete frankness is necessary. The men must understand that the methods and objects are not mysterious, nor designed for their detriment. Their reward should be commensurate to the hope held out to them, and the leading men especially should be shown consideration in the way of certain favors, such as being permitted to work on a particular machine, which is valued by them more highly than cold cash alone.

Open and Direct Methods Essential.

To dispel the feeling usually prevalent, that the methods are mysterious and ultimately injurious to their interests, it is well in making an improvement of any machine to point out to the operator just what needs are in view, just what time economies are expected, and it should be set before his reason that it is only fair the company should enjoy

some return on its investment which makes time reductions and output increases possible. Over against this picture of the company's interest, which will usually appeal to the fair-mindedness of a man, there should be set a statement of his own advantages under the new system.

Co-operation of Higher Officers Secured.

In order to enlist the coöperation of the higher officials, on whose authority alone such systems can be introduced, it has been found most advantageous to secure accurate time records under the old conditions, and under the new ones proposed, with a calculation of the quantity of the production in each case and the monthly or annual savings which may be effected under the changed method.

Publicity of Methods by Lectures.

To urge all of the men and to enliven a universal enthusiasm and ready will among them, lantern-slide views covering different phases of the betterment work, accompanied by a clear and not too technical address, are very effective. They are the more effective if the plain slides from well-taken photographs are supplemented and interspersed with moving pictures of active operations in the shop. We illustrate a few portions of films taken with this end in view.

The first shows a limited train of the road rushing out of the picture. This picture, while hackneyed in subject, nevertheless serves to inspire a certain patriotism for the road.

Next, the spectators are led into the shop, where they see a large overhead electric crane in the impressive act of lifting a locomotive off her wheels and placing her upon the blocks in the erecting shop. It may be mentioned that the total time consumed in performing this operation was two minutes and forty-five seconds.

Next, on this page, one of the expert and speedy mechanics in the act of planing a large locomotive frame. The motion is realistic, and the man's efforts, making every move count to advantage—to the company's advantage in time reduction and to his advantage in increased daily pay—are very effective. Moreover, the publicity given this man caused him to swell with pride, and among the spectators his friends share this feeling, and the others look forward to a time when they also may appear.

Another series would illustrate the greater effectiveness of pneumatic riveting hammers than of the old perspiring hand methods. This series would interest whatever boiler-makers may be present. In order that no department may be neglected, it is well to have illustrations also of blacksmith work.

It may be stated that the preparation and carrying through of photographic illustrations of methods on such a large scale is an expensive process, running far up into the hundreds of dollars. But this investment is quite cheap when it is considered that these views are not only shown in one shop, but may be taken from shop to shop, from town to town, instilling interest into shop men, engineers, and all others whose helpfulness is worth anything. Such an instrument of publicity and frank exposition is invaluable in averting organized dissension and distrust on the part of the men. Especially is this true when there is a strike on the road and the men filling the strikers' places are under uncertainty and trepidation as to their treatment by the company.

The treatment of the human elements in the problem of railway machine-shop management is, however, large enough for a series in itself, and quite too large to be dismissed in a few paragraphs concluding a review which has followed only broad outlines in the administrative policies and mechanical equipment and processes of the shops. With this number, the discussion must be closed for the present. I hope even in this limited scope it has sufficed to show the large opportunity open for the betterment of railway machine-shop operation, and the efficacy of the means available for the reduction of costs and the maintenance of the operative efficiency of the motive power and rolling stock.

Betterment Methods Demonstrated in Practice.

The betterment methods detailed in these papers are not untried ideals from an over-theoretical mind; they are for the most part drawn from the practical application and development now in process, of such a broadly conceived plan on one of the largest Western railway systems of the United States, and from them great additional net earnings and improved power conditions have already resulted.

While, however, this economy and increase of efficiency has been accomplished through the agency of those methods, the credit for the accomplishment must be given, as always, not to the ~~mere~~ methods themselves, but to the man who has the temerity to push them through the inherent impedence of practices and mentalities rooted firmly by long usage and establishment. The vice-president in charge of operation of this railroad, Mr. J. W. Kendrick, has had more than the courage of his convictions; he has had the rare quality of infusing into his men an enthusiastic coöperation unequaled in the inauguration of a new order of things.—H. W. Jacobs, *in Engineering Magazine, September, October, November, December, 1906, and January, 1907.*

THE RELATION BETWEEN THE MECHANICAL AND STORE DEPARTMENTS.

IN this age of specialization we find the store and mechanical departments of a railroad handled by men who are specialists in their line. Their duties overlap in the matter of mechanical department supplies. Unless there is "team work" or harmony between them, the good efforts of one may be entirely offset by the shortcomings of the other.

The mechanical department's conception of an ideal store department is one that can fill immediately each and every requisition. To do this, the store department must carry a complete stock, the individual items of which are obtained either in the market or from the shops of the system, and to accomplish this the store department must make use of its previous records, determining how much and what stock to carry, and must also be informed by the mechanical department concerning future demands, changes in engine locations and changes in standards. In addition, the mechanical department should have confidence:

The Ideal Store Department.

(1) That the store department will take care of each and every call for material.

(2) That requisitions will be filled promptly.

(3) That requisitions will be filled correctly.

This is, in brief, a short outline of my idea of the storehouse problem from the mechanical standpoint.

The stock in hand is the matter of greatest importance in every storehouse. The aim should be to have a small live stock with as little money as possible tied up, and at the same time be able to fill requisitions as presented. The store department might come up to all requirements from the mechanical point of view and yet be most inefficient from the standpoint of the owners of the road. Too much stock on hand is almost as much of a waste of money as not enough, not enough meaning loss of money through delays to engines and cars on the repair track waiting for material to be bought or made, and too much meaning loss of interest on money invested, deterioration in value on perishable articles, and danger of much becoming obsolete and worthless through change of standards.

Maintenance of Efficient and Economical Stock.

An example of how too much stock can be accumulated is the old story of the road with only two engines of a certain class which were moved from one division of the road to another, until these two engines had been over the entire system. After they had been on the road some two years and had been overhauled in three different places the president called for a statement of material in hand for these engines. There were found on hand scattered along the line fourteen sets of grates, nine sets of cylinder heads, four sets of pistons, two complete sets of rods, besides numerous cylinder-head casings, valve packings, piston rings, etc.; in fact, more material in stock than these two engines would use in ten years.

Example Showing Cause for Excessive Stock.

This is perhaps an unusual case, but it is actual, and the fault was that each master mechanic was trying to protect these two engines while they were on his division. With an efficient store department none of this material would have been in the hands of the mechanical department, but instead there would have been a reasonable amount in the hands of the store department, who would have moved it from division to division as the engines were transferred.

This shows the difference between what happens when an efficient store department handles this problem and what occurs when the same thing is left to the mechanical department, who are not specialists in this particular line.

The railroad that does not carry a full stock of material in the hands of an efficient store department is very short-sighted. I find that if the store department does not carry the necessary amount of stock, each gang boss, roundhouse foreman, shop superintendent and master mechanic takes it upon himself to run his own little private storehouse for his needs as he sees them. This means an innumerable number of duplications, no records or system, and much time wasted hunting for material supposed to exist but which either never did exist or has been lost.

Economy of Complete Stock.

This material is collected in numerous ways. The most common is by ordering more than needed when making requisitions and putting the extra pieces in the private stock. The only excuse for this system is that the value of the stock on hand does not show in the books of the company. This is a disastrous policy, for the stock exists, and is much more in quantity than would be needed by an efficient store department. On a road I have in mind this private stock collected by self-appointed storekeepers in the mechanical department contained every part of a

FIG. 102—STORAGE PLATFORM AND RACKS FOR FINISHED MATERIAL AT CENTRAL SHOPS, AND INTERIOR OF STOREROOM ILLUSTRATING THE RESULTS OF CENTRALIZED PRODUCTION OF SUPPLIES FOR A MODERN RAILWAY STORES ROOM. THESE PLATFORMS AND SHELVES ARE ARRANGED SYSTEMATICALLY AT EACH STOREHOUSE BY GROUPS, BEING DESIGNATED BY CLASS LETTERS, WHICH ARE IDENTICAL FOR EACH STORE ON THE RAILWAY SYSTEM, THUS MAKING IT A SIMPLE MATTER FOR ANYONE FAMILIAR WITH THE METHOD TO LOCATE ANY PARTICULAR ITEM OF MATERIAL. THIS SYSTEM WAS ORIGINATED AND PUT INTO PRACTICAL PAYING EFFECT BY A SUCCESSFUL GENERAL RAILWAY STOREKEEPER WHO HAS PROBABLY DONE MORE THAN ANY OTHER MAN IN HIS PROFESSION IN THE COUNTRY, TO REDUCE RAILWAY STOREKEEPING TO A SCIENCE.

locomotive from a piston gland to a boiler, complete. Such a state of affairs does not exist today on this road.

An efficient store department can reduce the quantity of stock by taking complete charge of it, keeping complete records of its location, and distributing it geographically to correspond with the class distribution of engines.

The mechanical department can further aid the store department to reduce the quantity of stock required, and also the value of it, by standardizing all material to the greatest possible extent.

Reduction in Number of Parts by Standardization.

Standardization reduces quantity. As an example, if of one hundred classes of engines the main rod key is different for each class, the store department must carry at least three hundred keys to protect every engine; if, however, these keys were standardized so that one style of key could do for every engine, then a stock of fifty keys would be ample to protect all of the one hundred classes. Standardization reduces cost, as large quantities of duplicate pieces are ordered at one time and consequently the cost of manufacture per piece can be materially decreased.

As an example of the economy of manufacturing standard parts in quantities rather than in separate pieces each time, the tables on the following pages are quoted, showing the saving in labor costs in material manufactured in central shop.

Every railroad man today has reached the point of believing in standardizing. There is little to be gained in making standard parts unless these parts are to be made in quantities and distributed by an efficient store system.

Standardization also permits of going into the open market for standard parts. This is more the province of the purchasing rather than the store department, although the store and mechanical departments are both concerned in the value of their material.

Manufactured Material Costs.

In bringing up the matter of costs we find many different systems of determining them. The value of material bought in the open market is easily determined, as the invoice takes care of that. The cost of material manufactured on the road as listed on storehouse books is usually low compared with market prices. The value of manufactured material is commonly figured as direct labor cost plus material cost, and I find some roads adding from two to ten per cent to their labor to cover handling and other direct expenses. These figures are ridiculously low, as manufac-

ECONOMY EFFECTED BY CONCENTRATION OF MANUFACTURE OF CERTAIN LOCOMOTIVE PARTS AT CENTRAL SHOP.

Article.	*Total Number used per month.*	*Actual Labor Cost at*	*Average Labor Cost at Outside Points.*	*Actual Labor Saving per Month.*
Bull Rings	20	$0.20	$0.70	$10.00
Blower Elbows	50	.38	.60	11.00
Crosshead Pins	40	.26	1.35	43.60
Cylinder Heads, assorted	72	1.55	2.10	39.60
Crossheads, assorted	30	1.90	4.10	66.00
Crank Pin Collars	70	.15	.80	45.50
Crank Pins	60	.50	1.75	75.00
Chafing Irons	60	.30	.75	27.00
Cylinders	12	14.40	32.50	217.20
Driving Boxes	55	1.45	3.10	90.75
Drawbar Carryirons	..	.02	.28	......
Driving Box Binders	24	.15	.22	1.68
Eccentrics	70	1.05	2.32	158.90
Eccentric Straps	44	.90	2.50	70.40
Engine Bolts, Centering, Roughing and Threadings	13562	.01	.09	1084.96
Engine Truck Boxes	16	.24	.68	7.04
Exhaust Nozzles	8	.65	1.22	4.56
Follower Plates	30	.40	..	15.60
Grease Cups	825	.08	.92	115.50
Grease-Cup Plugs	2500	.01	.22	15.00
Knuckle Pins	200	.26	.07	318.00
Niggerheads	6	.21	1.85	4.44
Piston Rods	48	1.65	.95	284.64
Packing Glands	50	.24	7.58	27.00
Piston Valves, assorted	15	1.75	.78	93.75
Piston Valve Bushing	12	3.33	8.00	77.64
Packing Rings	600	.08	9.80	384.00
Piston Heads	48	.95	.72	91.20
Rocker Boxes	30	1.11	2.85	62.70
Steam Chests	10	1.50	3.20	28.00
Steam Pipes	20	.65	4.30	11.00
Shoes and Wedges	450	.07	1.20	337.50
Slide Valves, assorted	5	1.95	.82	9.35
Stack Saddles	6	.38	3.82	2.04
Safety-Chain Hooks	30	.17	.72	9.90
Switch-Chain Hooks	40	.15	.50	10.00
Sand Pipes	8	.20	.40	2.56
Spiders	20	.10	.52	18.20
Tumbling-Shaft Boxes	16	.17	1.91	4.96
Wrenches, Grease Cup	100	.16	.48	29.00
Wrenches, Car Repairers'	1000	.025	.45	175.00
Lathe and Planer Tools	400	.16	.20	175.00
Brake-Shoe Keys	2500	.001	.60	122.50
				$4,513.67

TABLE SHOWING LOCOMOTIVE PARTS THAT CAN BE MANUFACTURED AT A CENTRAL SHOP WITH THE PRESENT FACILITIES.

ARTICLE.	*Total that could be made per Month.*	*Time on Each.*	*Used at per Month.*	*Surplus.*	*Store-keeper's Requirements.*
Bull Rings	75	1.4	20	55	20
Blower Elbows	60	1.5	..	..	50
Crosshead Pins	40	.6	14	26	40
Cylinder Heads, assorted	50	4.0	15	35	72
Crossheads, assorted	25	5.5	8	17	..
Crank Pin Collars	225	.6	25	200	30
Crank Pins	50	1.4	10	40	60
Chafing Irons	65	1.4	8	57	60
Cylinders	15	45.0	8	7	12
Driving Boxes	80	3.7	10	70	55
Drawbar Carryirons	2000	...	..	..	..
Driving Box Binders	25	.4	6	18	24
Eccentrics	100	2.5	15	85	70
Eccentric Straps	100	5.2	15	85	44
Eng. Blts., Centering, Roughing and Threading	14000	.05	4000	10000	13562
Engine Truck Boxes	60	.3	8	52	16
Exhaust Nozzles	12	1.6	4	8	8
Follower Plates	75	1.0	20	55	30
Grease Cups	1000	.3	150	850	825
Grease-Cup Plugs	7500	.05	300	7200	2500
Knuckle Pins	300	.25	60	240	200
Niggerheads	30	.6	..	..	..
Piston Rods	80	4.1	10	70	42
Packing Glands	250	.6	50	200	50
Piston Valves, assorted	60	4.5	8	52	15
Piston Valve Bushing	40	8.0	10	30	12
Packing Rings	1200	.3	200	1000	600
Piston Heads	50	2.6	18	32	48
Pilots (new)	50	...	..	..	..
Pilot Bands (new)	50	...	..	..	..
Rocker Boxes	8	2.9	8	..	30
Steam Chests	30	4.0	5	25	10
Steam Pipes	75	2.0	8	67	20
Shoes and Wedges	450	.6	125	305	450
Slide Valves, assorted	10	4.8	3	7	5
Stack Saddles	15	1.0	4	11	6
Safety-Chain Hooks	100	...	..	..	..
Switch-Chain Hooks	100	...	..	..	..
Sand Pipes	10	.5	4	6	8
Steam-Chest Covers	50	.9	3	47	16
Spiders	45	2.8	15	30	20
Tumbling-Shaft Box	30	.4	5	25	16
Wrenches, Grease Cup	100	...	..	..	..
Wrenches, Car Repairers'	1000	...	..	..	..

turers find that overhead or surcharge expenses are often two and three times the direct labor.

It is not important that cost be figured accurately when the material is only passed from one department of a road to another as from mechanical to store, or from one division to another. It is in this case simply taking from one pocket and putting in another. So far as the railroad is concerned as a whole, there would be no loss of money if no charges at all were put on the material manufactured in their own shop.

One department can give to the other and there is no decrease in actual cost to the road.

Unless these costs are figured completely and accurately, there is no use in taking them as a basis of value. In such cases I would advise keeping track of quantity only and paying no regard to value.

It is important that values be known accurately when the question arises of buying or making certain articles. All the cost of rent, supervision, machinery, power, heat, light, etc., enters into the cost of each

Surcharge Item Costs.

repaired engine or engine part delivered from the locomotive repair shop. Until these items are all prorated over the cost of the shop output, no comparative figures as to value are obtained.

These items make up the surcharge problem, and are just as real a part of the cost as the material or the labor which we call direct and locate. Direct labor and unlocated cost each enter into the final value of an article just as much as power to move a balanced compound engine is developed in both the high-pressure cylinders and low-pressure cylinders. The high-pressure cylinders may be between the frame and not in evidence to the untrained eye, but these cylinders must be considered in figuring tractive force or we underestimate it in about the same proportion as we underestimate costs if we do not include the surcharge, which is no more evident to the untrained mind than the high-pressure cylinders of a balanced compound are to a farmer.

The store department should realize that the mechanical department will not order a thing unless they need it. The mechanical department wants what it orders and not something "just as good."

Commercial advertisements are full of cautions to beware of something "just as good," and mechanical men, gang bosses, will always be wrought up if the store department attempts to fill their requisitions with something "just as good," as that ordered.

I have said the mechanical department will not order anything

FIG. 103—A MODEL RAILROAD SHOP MATERIAL PLATFORM. ON THIS PLATFORM, LOCOMOTIVE CASTINGS AND PARTS WHICH HAVE BEEN MACHINED TO SIZE ARE STORED READY FOR SHIPMENT TO OUTLYING SHOPS. THIS ALSO ILLUSTRATES THE GOOD WORK DONE BY A PROGRESSIVE GENERAL STOREKEEPER.

unless they need it. This statement should be modified, for unless close watch is kept of the foreman making requisitions they will continually order from two to three times what is needed, in their great caution to protect themselves. It is, however, hardly in the province of the store department to dictate as to what the foremen shall order, unless they are ordering material which is not standard.

The mechanical department should aid the storehouse to have a competent person pass on all requisitions and see that only the required amount and class of material is ordered. At a certain point where shops are located, which I have in mind, this official is known as the material supervisor, and the results of his work have been a decided decrease in the amount of material ordered for engines being repaired.

Supervision of Requisitions for Material.

The ordinary gang foreman, when given a requisition book, acts very much as you or I would if we were given a check book and told that our personal check was good for any amount we cared to draw. We would soon have to have a material supervisor or some other officer appointed to watch us to see that we did not order two suits of clothes when one would do; turkey and plum-pudding for breakfast when bacon and eggs would be much cheaper and more for our own good.

I have said that the ideal storehouse should fill every requisition when presented. This means that everything should be carried in stock and all requisitions filled from stock.

Requisitions Returned When Not Filled.

I would have the store department return to the maker every requisition it cannot fill in three days or a reasonable length of time, and with the return should be a notice to show when it was expected this material would be in stock.

The maker of the requisition then makes his plans to meet existing conditions. If there is no chance to get the material until some time long after he needs it, he will make arrangements to use something else. If, on the other hand, the material is expected in stock soon enough to meet his needs, he will send another requisition or return the first one at a later date.

It was once very common on a certain system to find material being delivered to their repair shops for certain engines, weeks and sometimes months after the engines had gone into service. I do not doubt other roads had the same experience. This material was without doubt needed when ordered, but when the requisition failed to be filled

promptly the shop managed to get along without it, and of course when delivery was made had no use for it.

The case is like that of a man who would order breakfast at 7 A. M., but the delivery was not made until 3 P. M. Our friend would probably not want breakfast then, as he would have had dinner in the meantime, and this breakfast delivered at 3 P. M. is only a nuisance to him. The only thing he can do with it is to put it away in hopes he can put his hand on it at 7 A. M. the next morning. This is one way in which private stocks are accumulated by the foreman. How much better it would have been if the requisition for breakfast at 7 A. M. had been returned immediately, with the notice that it could not be filled until 7 A. M. tomorrow. Our friend could then have arranged to get next to a free-lunch counter this morning or made other arrangements to keep him going until his source of supplies, the storehouse, was able to take care of his needs.

A similar illustration carried to the same absurdity happens in the case of a summer suit ordered for June delivery, which the tailor does not deliver until the following December. This friend would be much better off if at the time of ordering his suit he is told the delivery will not be made until December. He will then patch up his old last summer's suit and change his requisition from summer to winter goods.

Summary of Conditions.

Summing up conditions as they should be:

(1) The mechanical and store departments should be entirely separate.

(2) The men in each department should be specialists in their line.

(3) Team work and harmony must exist between them as regards the matter of mechanical supplies, as in this matter the duties of both overlap.

(4) The store department must take complete charge of all material, and must be in a position to deliver the goods when called upon to do so.

(5) The mechanical department must have confidence in the store department, and not set up private storehouses of its own.

(6) If the store department fails to furnish material as called for, individuals in the mechanical department take it upon themselves to run their own storehouse.

(7) These private stocks run into immense amounts of money in the innumerable duplications, no system and no records.

(8) The store department must keep the quantity and value of stock as low as possible, and at the same time be able to fill all requisitions as presented.

(9) The quantity and value of stock can be reduced by the standardizing of all materials.

(10) All requisitions should be filled promptly.

(11) Requisitions which cannot be filled in a reasonable time should be returned to maker, accompanied by a notice as to when the material should be in the storehouse stock.

A paper presented by H. W. Jacobs *before the Fourth Annual Railway Storekeepers' Convention.*

SHOP EFFICIENCY.

CONSIDERABLE attention has recently been given to the various phases of the betterment work on the Santa Fe, the most important of which is that of shop costs, with its factors, individual efficiency as to labor performed and the scientific scheduling of engines through the shop. The paper on this subject presented by Mr. A. Lovell, superintendent of motive power of the Santa Fe, before the recent meeting of the Master Mechanics' Association, attracted considerable attention. As a paper of this kind has limitations as to length, it may not be amiss to supplement, with more extensive illustrations and examples, some phases of the subject, which it was not possible to fully develop in the paper.

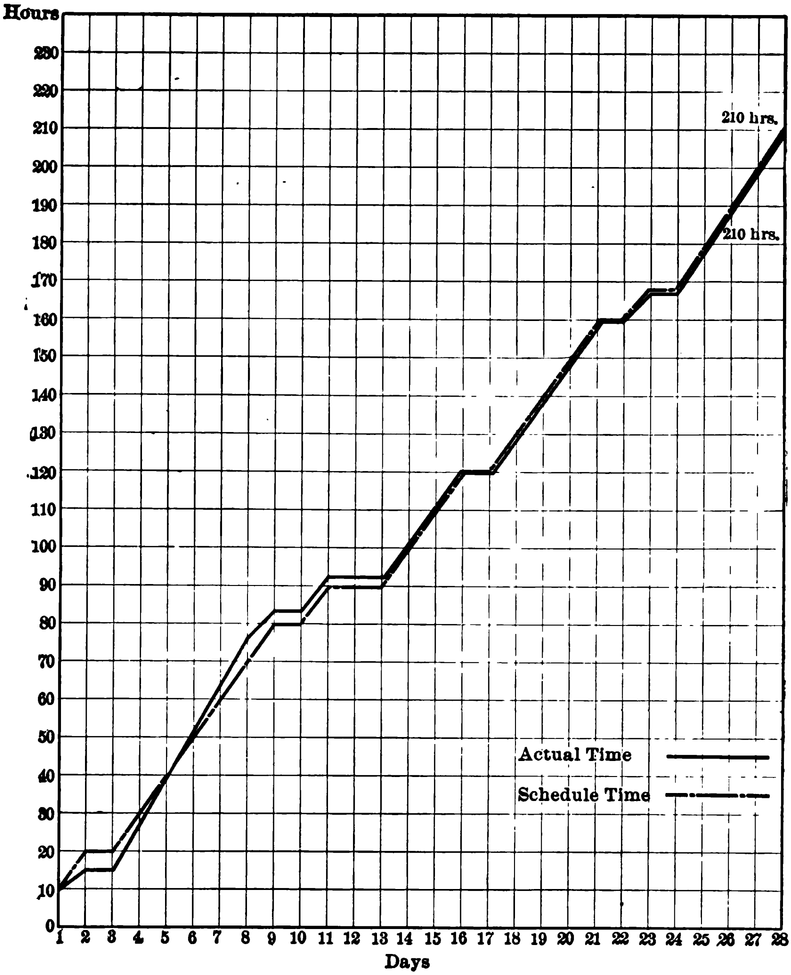
The cost problem, while it is helped by the introduction of carefully prepared shop schedules, which are "lived up to," is by no means solved. The problem involves each individual workman, and to solve it some method must be adopted that will cause each man to work at his highest average efficiency. This does not mean that he is expected to over-exert himself, but that he is to cut out all unecessary delays and wastes. The method adopted to accomplish this result was the introduction of the individual-effort method or bonus system, by which each man is able to increase his earnings as he increases his average efficiency.

Individual Effort, High Efficiency and Low Costs.

One very noticeable fact is that the older men are among the highest bonus-earners, which is probably due to the fact that they depend to a greater extent upon using their brain power to utilize their available strength, than do the younger men. The accompanying chart, Fig. 105, illustrates the work done by one of the older men in February, and is in several respects ideal.

It shows the result of steady and insistent work, day by day. The full line shows the actual hours worked, which totals 210, while the broken line shows the standard work hours accumulated, which also totals 210, making the man's efficiency for the month 100 per cent. The standard hours are determined by schedules which assign a given time for each operation. The bonus inspector checks up the jobs performed by each man every day, and the standard hours accumulated are credited to him.

Record of Good Workman.



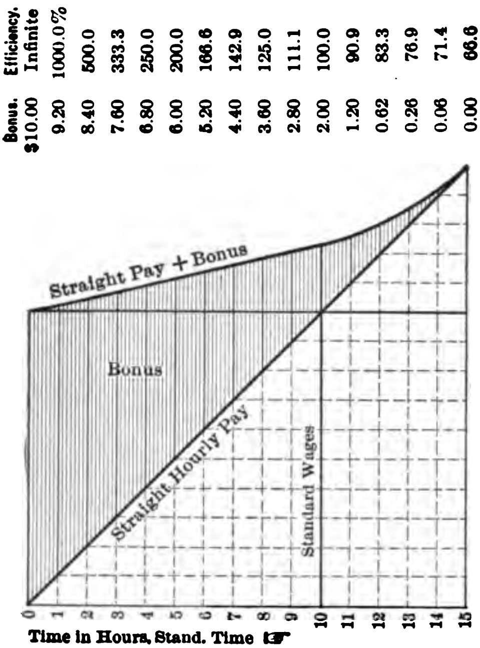
PERSONAL RECORD OF L. J. W.

February 1907.

Efficiency, 100%. **210 hours.** **Rate, 40c. per hour.** **Wages, $84.00.** **Bonus, $16.80.**
Total, $100.80.

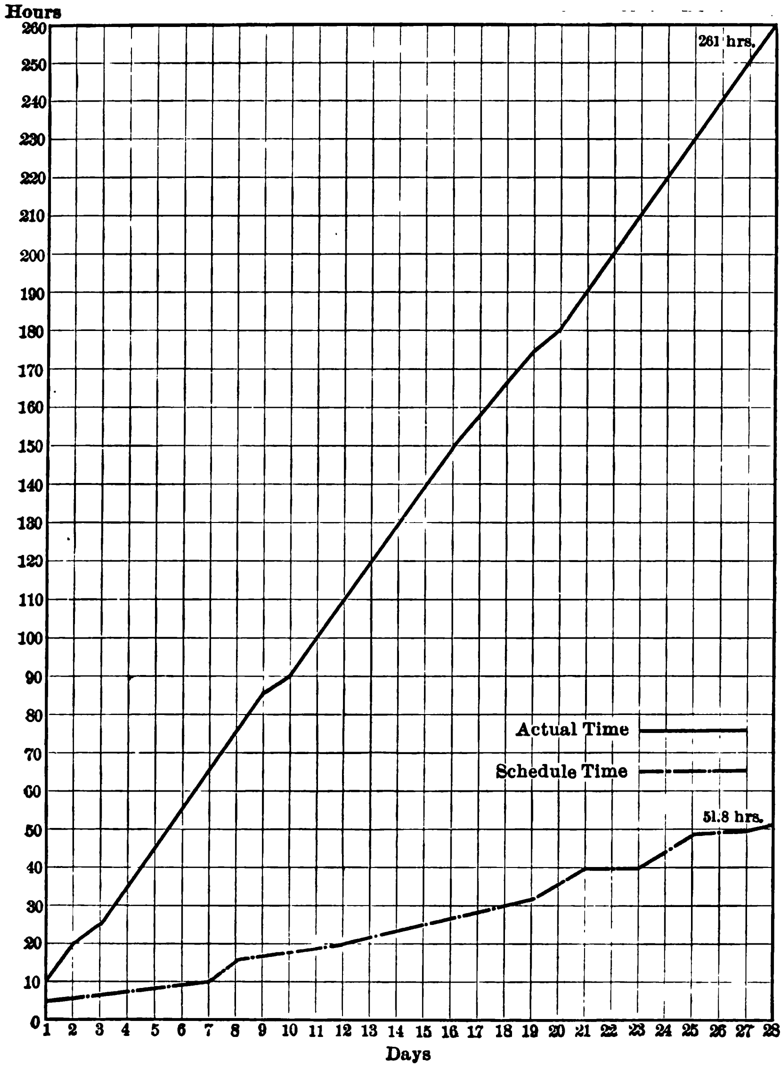
FIG. 105—INDIVIDUAL EFFICIENCY OF A GOOD WORKMAN.

TABLE AND DIAGRAM SHOWING METHOD OF CALCULATING BONUS IN ADDITION TO REGULAR WAGES.—RATE AT $1.00 PER HOUR.



Wages	+ Bonus	= Total.	Bonus / Wages.	Efficiency.	Rate.
$15.00	$0.00	$15.00	0.0%	66.6%	$1.00
14.00	0.06	14.06	0.4	71.4	1.004
13.00	0.26	13.26	2.0	76.9	1.02
12.00	0.62	12.62	5.2	83.3	1.05
11.00	1.20	12.20	10.7	90.9	1.109
10.00	2.00	12.00	20.0	100.0	1.20
9.00	2.80	11.80	31.0	111.1	1.31
8.00	3.60	11.60	45.0	125.0	1.45
7.00	4.40	11.40	72.7	142.9	1.63
6.0C	5.20	11.20	86.6	166.6	1.86
5.00	6.00	11.00	120.0	200.0	2.20
4.00	6.80	10.80	170.0	250.0	2.70
3.00	7.60	10.60	253.3	333.3	3.53
2.00	8.40	10.40	420.0	500.0	5.20
1.00	9.20	10.20	920.0	1000.0	10.20
0.00	10.00	10.00	Infinite	Infinite	Infinite

FIG. 106—CURVE FROM WHICH AMOUNT OF BONUS IS CALCULATED.

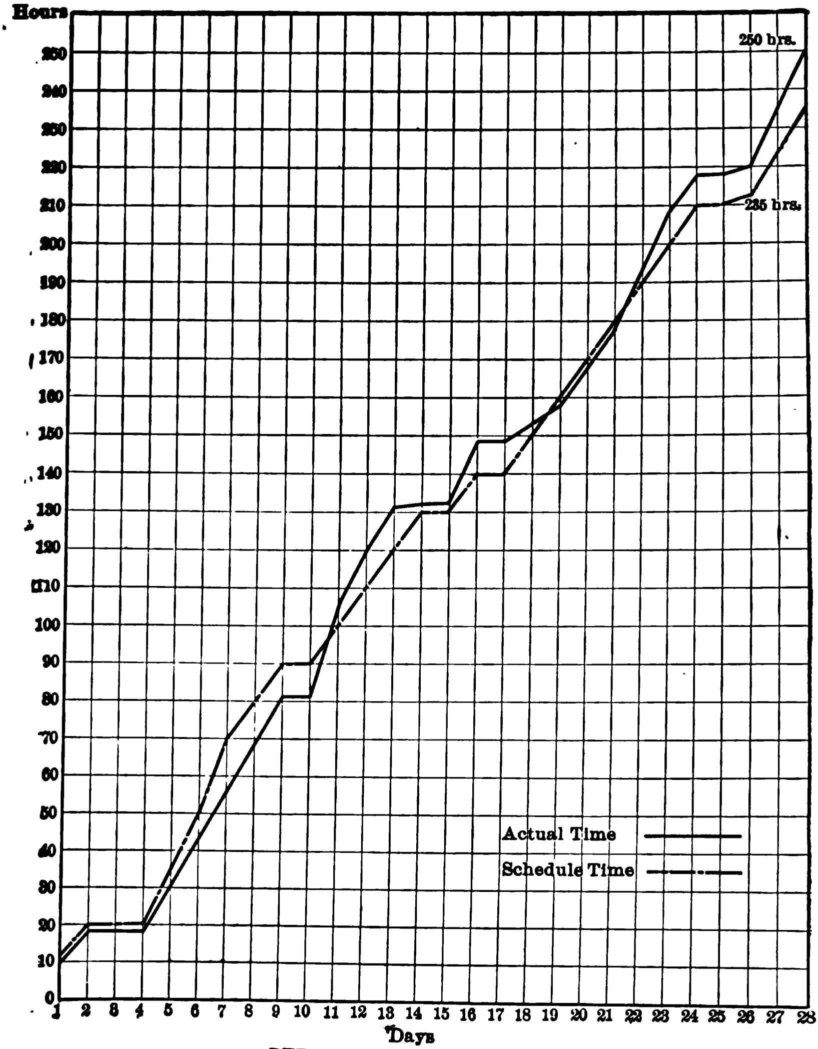


PERSONAL RECORD OF J. D. H.

February 1907.

Efficiency 20%.			Average rate 30c. per hour		
Efficiency.	Hours.	Rate.	Wages.	Bonus.	Total.
20%	261	30c.	$78.30	$——	$78.30
100%	51 8	30	15.54	3.10	18.64
				Loss to company:	59.66
100%	261	30	78.30	15.66	93.96
20%	261	30	78.30	——	78.30
				Loss to man:	**15.66**

FIG. 107—EFFICIENCY RECORD OF A POOR WORKMAN



PERSONAL RECORD OF J. H. B

February 1907.

Efficiency 94%.			Average rate 38c. per hour.		
Efficiency.	Hours.	Rate.	Wages.	Bonus.	Total.
94%	250	38c.	$95.00	$12.85	$107.85
100%	235	38c.	89.30	17.86	107.16
				Loss to company:	0.69
100%	250	38c.	95.00	19.00	114.00
94%	250	38c.	95.00	12.85	107.85
				Loss to man:	6.15

FIG. 108—EFFICIENCY RECORD OF A SPASMODIC WORKMAN.

As an example, a lathe operation may have a record as follows:

	Standard Time.	*Actual Time.*
Turn three eccentrics (at 1.3)	3.9	3.3
Turn two small eccentrics (at 1.0)	2.0	1.7
Turn and bore complete six lateral swing castings (at 0.4)	2.4	2.0
Turn and fit complete two knuckle pins (at 1.5)	3.0	3.0
TOTAL	11.3	10.0

Eleven and three-tenths hours would then be credited to his efficiency account for the day's work.

The following practical example of cost study is taken from one of the shop time-cards from which the workman's wages, bonus and personal records are deduced:

TRUING MALLEABLE IRON PISTON HEAD.

Machine No.	0561	
Machine Hour Rate	$0.36	
Man's Rate	0.34	
Surcharge to Man	90	per cent.
Schedule Time	2.2	hours.
Actual January Record	2.25	hours.

AVERAGE COST OF EACH OPERATION DURING JANUARY.

Wages	$0.765
Surcharge	0.69
Bonus	0.13
Machine charge	0.81
TOTAL	$2.395

Quality of Material and Production Costs.

An unusually hard malleable iron piston head was delivered to the operator, who at once protested, as he saw that there would be no opportunity for earning a bonus. The work was completed in 8.3 hours. The cost of the operation, in detail, was as follows:

Wages	$2.82
Surcharge	2.54
Bonus	0.00
Machine charge	2.99
TOTAL COST	$8.35
Cost with normal iron	2.39
LOSS	$5.96

Total increase of cost due to hard iron, 250 per cent. This piston head was so badly cracked in putting it on the piston rod that it had

to be scrapped, and the net loss to the company was $18.40, as shown below:

Cost of turning head	$8.35
Cost of labor for putting heat on rod	0.18
Surcharge, 45 per cent of $0.18	0.08
Weight of head, 535 lbs., at $0.025 per lb	13.38
3 per cent for handling material	0.41
TOTAL COST	$22.40
Scrap value, at $0.0075 per lb	4.00
NET LOSS	$18.40

Under the efficiency plan it becomes incumbent on the man to register a protest against improper or defective material to protect his own interests, and this institutes a close check on the quality of material delivered to the company.

At 100 per cent efficiency the workman receives a bonus of 20 per cent of his wages. For example, the man represented in the chart, Fig. 105, has earned 210 times 40c. or $84, and a bonus equal to 20 per cent of this, making his total income for the month $100.80. For efficiencies below 100 per cent the bonus is taken from efficiency tables, which are calculated from the bonus curve, Fig. 106.

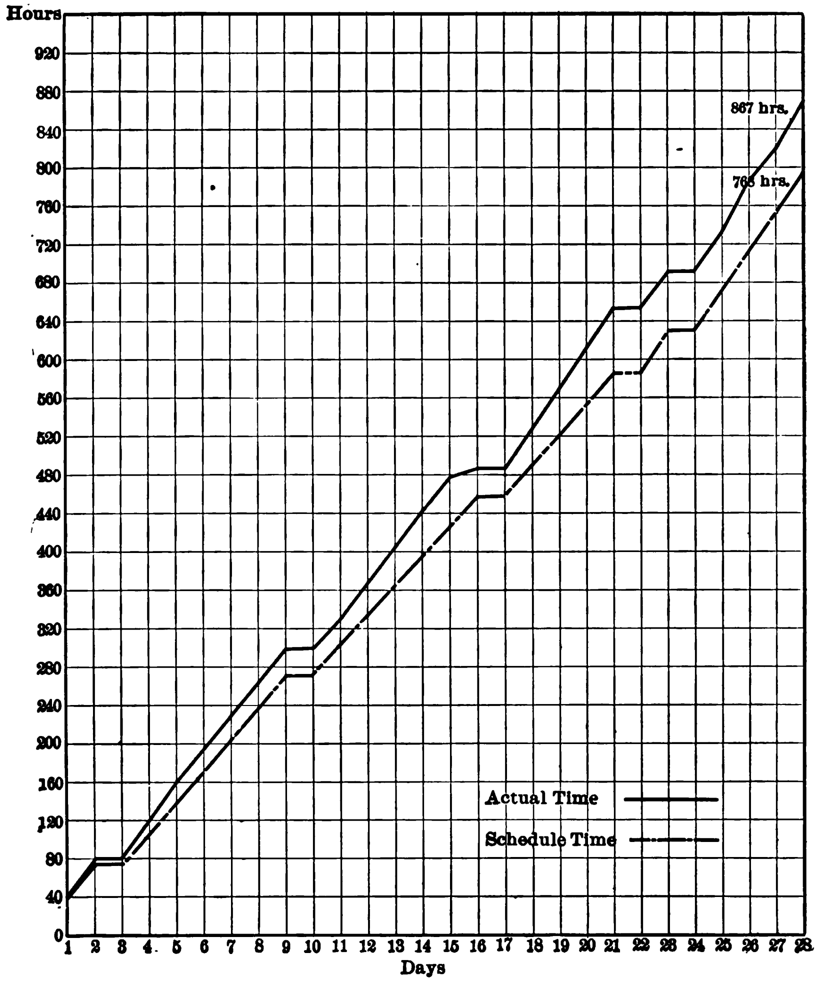
Record of Poor Workman.

Fig. 107 illustrates the work of a poor workman, his efficiency being only 20 per cent. His wages for 261 hours at 30c. amounting to $78.30. According to the schedules the man should have done the same amount of work in 51.8 hours, which at 30c. an hour and with the 20 per cent. bonus would have made the total cost to the company $18.64. Due to the inefficient performance of this man, the company therefore lost $59.66. If he had attained an efficiency of 100 per cent in 261 hours he would have had a bonus coming to him of $15.66 in addition to his wages of $78.30, which would have given him a total income of $93.96 for the month. It will be noted that this man worked every Sunday in the month, and that he also worked overtime. This undoubtedly had something to do with his low efficiency.

The work of an unsteady and spasmodic workman is illustrated by the diagram in Fig. 108.

Record of Spasmodic Workman.

Such a man can do good work, but he is not to be depended upon. If his foreman should want him for a rush job he is very apt to lay off, or work at a low efficiency, and is apparently of a somewhat emotional nature.

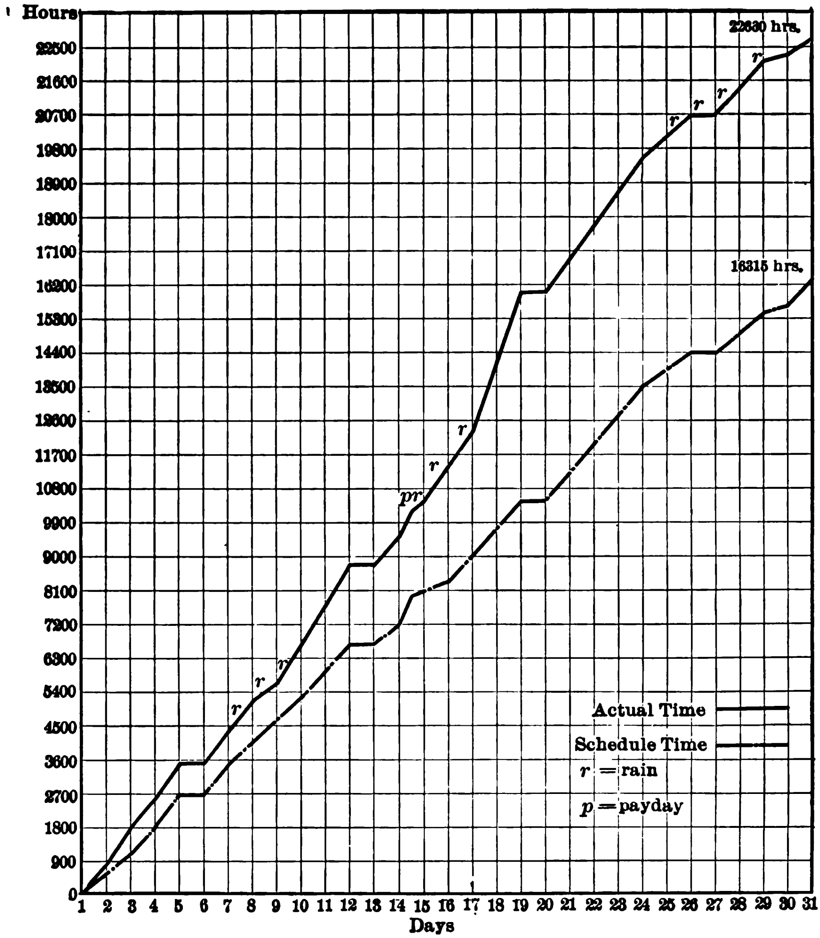


RECORD OF DRY PIPE GANG.

February 1907.

Efficiency.	Efficiency 88%. Hours.	Rate.	Average rate 30c. per hour. Wages.	Bonus.	Total.
88%	867	30c.	$260.10	$19.16	$279.26
100%	768	30c.	230.40	46.08	276.48
				Loss to company:	2.78
100%	867	30c.	260.10	52.02	312.12
88%	867	30c.	260.10	19.16	279.26
				Loss to men:	32.86

FIG. 109—EFFICIENCY RECORD FOR DRY-PIPE GANG.



RECORD OF REPAIR TRACK.

January 1907.

Efficiency.	Efficiency 72%. Hours.	Rate	Average rate 23c. per hour. Wages.	Bonus.	Total.
72%	22660	23c.	$5109.73	$839.66	$5949.39
100%	16315	23c.	3752.45	750.49	3502.94
				Loss to company:	2446.45
100%	22660	23c.	5109.73	1021.94	6131.71
72%	22660	23c.	5109.73	839.66	5949.39
				Loss to men:	182.32

FIG. 110—EFFICIENCY RECORD OF REPAIR-TRACK GANGS.

Efficiency charts for the different gangs and departments or for the entire shop are plotted the same as for the individual workers. Fig. 109 shows the work of the dry-pipe gang for February, its efficiency for that month being 88 per cent.

Efficiency Record of Dry-Pipe Gang.

The diagram in Fig. 110 shows the efficiency of the repair track for the month of January, during which time there were ten rainy days, the chart distinctly showing the effect of this on the efficiency. During the following month, February, there were less rainy days and the efficiency of the department increased from 72 to 85 per cent.

Efficiency Record of Repair Track.

Fig. 111 shows the efficiency of a shop as a whole. The total number of hours worked during the month was 129,470, and the standard time allowed for performing the various operations was 103,335, so that the shop efficiency was 80 per cent. The first day of the month being New Year's day, no work was done. The second day the men came to work and worked at a high efficiency, probably due to the fact that it was the beginning of the month. At the close of the third week the efficiency dropped off slightly, the week closing at a lower efficiency than at the beginning. The sixth day being Sunday, no work was done.

Efficiency Record of Entire Shop.

The second week the workmen began with a high efficiency, however showing slight signs of a decrease at the end of the eighth day, and slowly decreasing for the rest of the week. The thirteenth was Sunday, and no work was done.

The first two days of the third week the efficiency was high. The effect to pay day, the fifteenth, is shown by the falling-off in efficiency on the sixteenth. On the morning of the seventeenth the workmen began to work more efficiently, the week as a whole, however, showing the bad effect of pay day. The twentieth, Sunday, no work was done. The men began the fourth week with renewed efforts, their efficiency being high for the first day, but the next day it again began to drop, closing the week on the 26th with a much lower efficiency than any time during the month. The 27th was Sunday. The men worked very efficiently the rest of the month, falling off slightly on the last day.

The labor and bonus cost of scheduled work for the month at 80 per cent efficiency was $35,505.52, the total bonus paid amounting to $4,006.83. If this same work had been done at 100 per cent efficiency the labor and bonus cost would have been $29,822.63, including a bonus of $5,006.83, which would have made an increase to the work-

men of $1,000 and a reduction in the cost of the work to the company of $5,683.84. This clearly shows that the greater the bonus paid to the men, the cheaper the work becomes to the company.

RESULTS.—RECORD OF INDIVIDUAL WORKMEN.—Knowing the efficiency of the individual workmen, their advancement to positions of greater usefulness can be automatically determined.

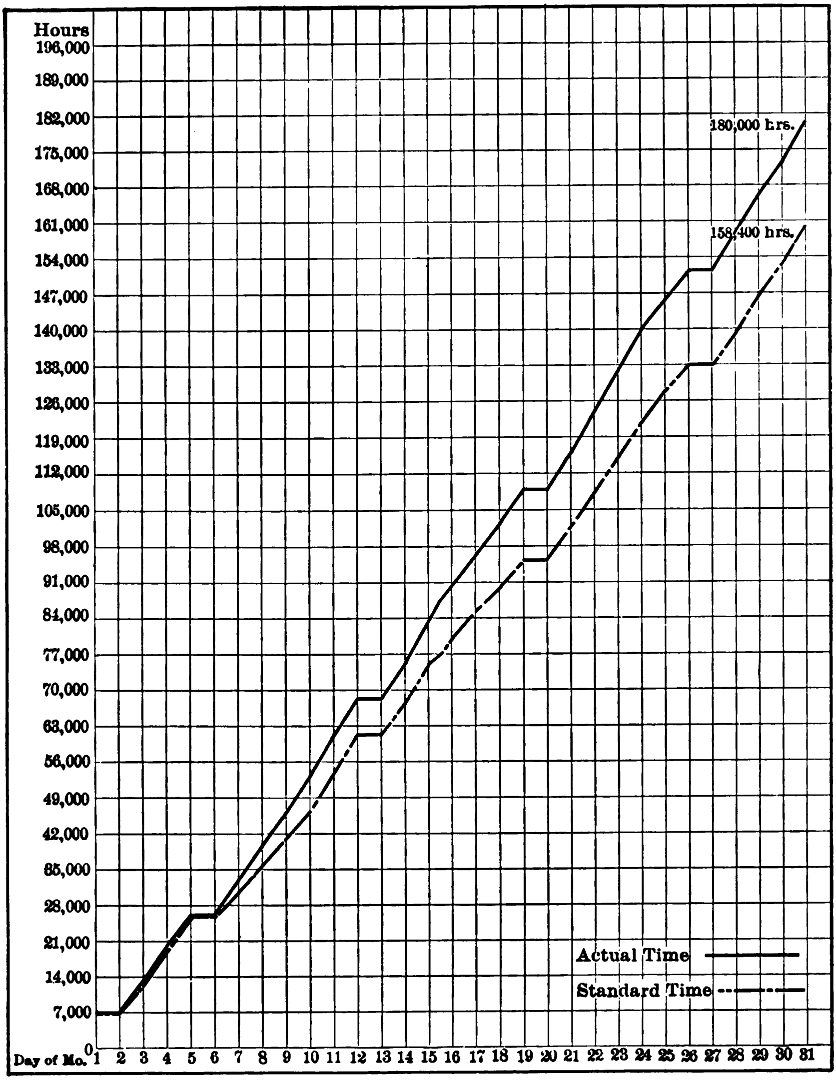
RECORD OF ENTIRE SHOP.—By setting "Standard Time" on each operation performed by each workman, after expert analysis of conditions, a totaling of standard times for all operations of all men and actual times can be determined, showing the efficiency of each shop department and for the shop as a whole. By thus determining the efficiency of different divisions shops a much better comparison of the amount of work turned out can be reached than by the old haphazard method of counting the mere number of engines or cars repaired. This old method is inconclusive owing to there being no set measure of the amount or character of the work done on each car or engine, nor of the condition of the car or engine when received at the shop and when again placed in service. The attempted classifications of character of repairs now in vogue are mostly based on the amount of money spent, with scarcely any reference to amount of work done. Such methods tend to show for the shop with poor organization and high and inefficient labor costs, a more creditable output than that of a shop with good administration and low and efficient labor costs.

General Results from Individual Effort System.

By having centralized supervision of detailed operation costs at each shop, it is mathematically practicable to determine the shop where each class of work can be most efficiently performed and the methods of the efficient shops can be applied to the places whose practice needs improvement.

The system as outlined has reduced the cost of repairs, raised the pay of the workmen, and established the output of the shops.

It is a task in itself to urge and develop practically such methods. It is a greater task to convert others into sympathy and coöperation with new ideas so that the workmen will not feel that it is a scheme to get something from them for nothing and to take away their liberty, but that they may be brought to realize that while the plan helps the railroad it also helps the workmen in a fair proportion.—H. W. JACOBS, *in American Engineer and Railroad Journal, October, 1907.*

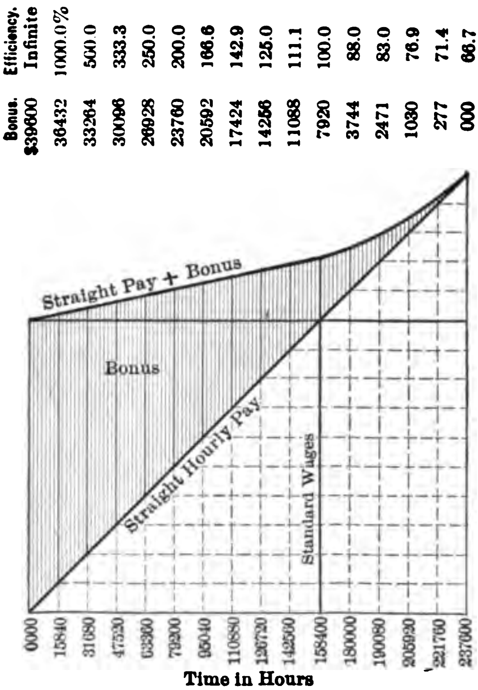


Efficiency.	Hours.	Man rate at 25c. per hour.	Surcharge at 40c. per hour.	Bonus.	Total.
88%	180,000	$45,000.00	$75,000.00	$3,744.00	$120,744.00
100%	158,400	39,600.00	63,360.00	7,920.00	110,880.00
				Loss to company:	9,864.00
100%	180,000	45,000,00	....	9,000.00	54,000.00
88%	180,000	45,000.00	....	3,744.00	48,744.00
				Loss to men:	5,256.00

Average rate per hour without bonus .... .25
" " " " with bonus at 88 per cent .... .275
" " " " " " " 100 " .... .30

FIG. 111—EFFICIENCY RECORD OF A SHOP.

TABLE AND DIAGRAM SHOWING METHOD OF CALCULATING BONUS IN ADDITION TO REGULAR WAGES.—ENTIRE SHOP.



Wages +	Bonus =	Total.	Bonus / Wages.	Efficiency.	Rate.
59400	$0000	$59400	0.0%	66.7%	$0.25
55440	277	55717	0.5	71.4	0.251
51480	1030	52510	2.0	76.9	0.255
47520	2471	49991	5.2	83.3	0.26
45000	3744	48744	8.3	88.0	0.275
39600	7920	47520	20.0	100.0	0.30
35640	11088	46728	31.0	111.1	0.33
31680	14256	45936	45.0	125.0	0.36
27720	17424	45144	62.9	142.9	0.41
23760	20582	44352	86.6	166.6	0.47
19800	23760	43560	120.0	200.0	0.55
15840	26928	42768	170.0	250.0	0.68
11880	30096	41976	253.3	333.3	0.88
7920	33264	41184	420.0	500.0	1.30
3960	36432	40392	920.0	1000.0	2.55
0000	39600	39600	Infinite	Infinite	Infinite

The above diagram represents the bonus or efficiency curve as applied to an entire shop or shop department. This example shows the collective standard output of 636 men each working a month of 250 hours, at an average rate of 25 cents an hour. If standard is not attained, but an efficiency of less than 100 per cent is made, a loss results both to the Company and to the men. For example: If the efficiency is only 88 per cent, the bonus earned by the men is $4176.00 less than if they had attained 100 per cent, and the work has required 21,600 more hours of time than the Company is paying for,—an excess cost of $9864.00. The loss to the Company on account of inefficiency is over 8 per cent of the labor cost alone, and the loss to the men nearly 11 per cent. It is thus evident that it is to the interest of the men, as individuals and collectively, and to the Company, to attain a maximum degree of efficiency for a maximum number of men.

Standard Form 1252, the monthly statement of bonus operations, gives an efficiency summary of each shop, so that master mechanics and other officers may have a ready index of where it will pay the Company in dollars saved on work done, to encourage and stimulate an increase in efficiency to the highest point.

SHOP EFFICIENCY.

EDITORIAL COMMENT BY AMERICAN ENGINEER AND RAILROAD JOURNAL, OCTOBER, 1907.

We are fortunate in being able to present, in this issue, an article on "Shop Efficiency," by Mr. H. W. Jacobs. It goes somewhat more into detail as to the method of determining the exact efficiency of the individual worker, gangs, or shops as a whole, than was possible in the paper presented at the recent meeting of the Master Mechanics' Association by Mr. A. Lovell on "Shop Cost Systems" (July issue), or in the article in our June issue, by Mr. Harrington Emerson on "The Methods of Exact Measurement Applied to Individual and Shop Efficiency at the Topeka Shops," or in the article by Mr. J. F. Whiteford in our June issue, on "Roundhouse Betterment Work." This matter of calculating the exact efficiency of the individual or shop was one of the later developments (and one of the most important) of the betterment work. To set a standard time for a piece of work, or to determine a reasonable cost for a certain operation or the maintenance of a piece of equipment, and then encourage the men to strive to reach it, is the key to the best work which has been done along betterment lines in our mechanical departments.

An important feature of the betterment work on the Santa Fe is that just as soon as possible the betterment department was merged into the regular mechanical department organization. At the present time four men, each having general supervision of the betterment work on a division, report directly to the assistant superintendent of motive power, Mr. H. W. Jacobs. These men are Mr. J. L. Sydnor, on the Coast Lines; Mr. C. J. Drury, on the Western Grand Division; Mr. E. E. Arison, on the Eastern Grand Division; and Mr. J. E. Epler, on the Gulf Lines. In addition to these Mr. Raffe Emerson assists Mr. Jacobs and Mr. J. F. Whiteford has general supervision of roundhouse work over the entire system. Bonus supervisors are located at each point. Mr. Clive Hastings handles statistical matters in connection with the betterment work, and reports directly to the 2nd Vice-President, Mr. J. W. Kendrick.

We have had so many requests for the special article on betterment work on the Santa Fe, published in our December, 1906, issue, and for other articles which have since appeared concerning the later developments, that it has been suggested that a list of all the articles touching on this work, which have appeared in our Journal, be published. These are as follows:

"Shop Betterment and the Individual Effort Method of Profit-Sharing," by Harrington Emerson. (A reprint of a pamphlet which was prepared for distribution among the workmen on the Santa Fe.)—Feb., 1906.

"Locomotive Repair Schedules," by C. J. Morrison. (A detailed description of the schedules in use at the Topeka shops.)—Sept., 1906.

"The Surcharge Problem," by C. J. Morrison. (A description of the method of determining surcharges and how they are applied.)—Oct., 1906.

The above article excited considerable discussion, and communications concerning it were published in the Nov. and Dec., 1906, issues. Mr. Morrison going into greater detail as to the exact methods of determining the surcharge. Other communications appeared in the Feb., 1907, issue.

"Betterment Work on the Santa Fe." (A complete study of the development of this work and the general and specific results which had been obtained to date. The article covered 26 pages.)—Dec., 1906.

Communications concerning the above article appeared in the Feb., 1907, and March, 1907, issues

"Dispatching Board for Engine Repairs," by C. J. Morrison.—April, 1907.

"Roundhouse Betterment Work," by J. F. Whiteford.—June, 1907.

"The Methods of Exact Measurement Applied to Individual and Shop Efficiencies at the Topeka Shops," by Harrington Emerson.—June, 1907.

Communications concerning the above article appeared in the July and August, 1907, issues.

"Shop Cost System and the Effect of Shop Schedules Upon Output and Cost of Locomotive Repairs," by A. Lovell. (A reprint of a paper presented before the Master Mechanics' Association, and an abstract of the discussion.)—July, 1907.

"Shop Efficiency," by H. W. Jacobs.—In this issue.

Editorial comments on the betterment work on the Santa Fe appeared in the Dec., 1906, issue; the Jan., 1907, issue, and June, 1907, issue.

STANDARDIZATION AND LABOR EFFICIENCY IN RAILROAD SHOPS.

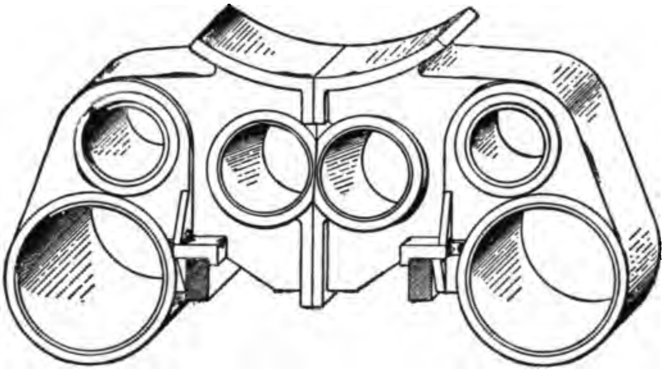
EDITORIAL COMMENT BY THE ENGINEERING MAGAZINE, AUGUST, 1907.

The Santa Fe has taken a leading place in the application of standardization and systematization to the efficient and economical management of railway shops, on the principles laid down in Mr. H. W. Jacobs's notable series of articles in recent numbers of *The Engineering Magazine*. Economy and efficiency of labor have been studies in great detail, and the remarkable results obtained at the Topeka shops form the subject of an interesting paper by Mr. Harrington Emerson in a recent number of the *American Engineer and Railroad Journal*. The paper is interesting also in offering a concrete example of the benefits to be derived from standardization, as described in an article on the economical utilization of labor reviewed in these columns last month. Mr. Emerson's article gives many tables and examples which it is impossible to reproduce, the following extracts giving only an outline of the methods employed and the results obtained.

"Shop efficiency pays. By shop efficiency is meant a careful investigation and betterment of all conditions, so that with the same effort men can accomplish more. To secure the coöperation of the worker with the management in cutting out unnecessary wastes at the Topeka shops of the Atchison, Topeka & Santa Fe Railway, he is offered an increase of as much as 20 per cent. If by means of special strength or skill he does more work than normal he is given all the gain; for instance, if he does in one hour a job standardized at two hours he receives two hours' pay for an hour's time. The management gains, firstly, by the elimination of unnecessary wastes, although it gives the worker a 20 per cent increase, and it particularly gains by the increased efficiency of its machines and other equipment, which results in a larger output without the necessity of increasing the capital investment. The actual results at the end of two years of systematically organizing the Topeka shops on an efficiency basis were:

To increase the average pay of the men 14.5%
To decrease the unit cost of production 36.3%
To increase the shop output 57.0%

"There is no reason why all the men should not earn at least a 25 per cent increase above standard wages, and many of them do, 40 per cent of them earning a 25 per cent increase and better. The average efficiency of all of the men in the month of April, 1907, was 94.2 per cent. Two years ago it was about 60 per cent. Although the average of all the workers is 94.2 per cent, there are many who are better, many who are not as good. One man earned 105.4 per cent above standard wages. Four men drawing full pay were 64.7 per cent below



CYLINDER CASTINGS FOR BALANCED COMPOUND PRAIRIE TYPE LOCOMOTIVE—INSIDE CYLINDERS INCLINED, 18 BY 28 IN. OUTSIDE CYLINDERS 30 BY 28 IN.

SCHEDULE TIMES FOR BORING COMPOUND CYLINDERS ON CYLINDER BORING-MILL, ILLUSTRATED ON PAGE 129.

a	All (3) Chambers—bored, counterbored and ends faced,	13.8 hrs.
b	L. P. Cylinder—bored, counterbored and ends faced....	5.9 hrs.
c	H. P. Cylinder—bored, counterbored and ends faced....	2.5 hrs.
d	Valve Chamber—bored, counterbored and ends faced...	1.9 hrs.
e	L. P. Cylinder—bored, one cut........................	1.1 hrs.
f	H. P. Cylinder—bored, one cut........................	.5 hr.
g	Valve Chamber—bored, one cut........................	.3 hr.

The standard machine schedules for boring complete compound and simple cylinders are as follows, expressing the time allowance in hours and tenths for convenience in time reckoning on the 24-hour system:

2A1–2 BORING COMPLETE—BALANCED COMPOUND. RATE, .36

Boring one (1) balanced compound cylinder ½ casting on cylinder boring-mill. Includes setting up, adjusting and clamping casting, rough boring, finishing, counterboring and facing both ends of three (3) chambers to blue-print. Casting unclamped and on floor. Per casting:

Time.

1—Classes 11, 12, 13, 14, 15, 16..........................00.0

2—Classes 21, 22...00.0

2A1–22 BORING COMPLETE—SIMPLE SLIDE VALVE. RATE, .36

Boring one (1) simple slide valve cylinder ½ casting on cylinder boring-mill. Includes setting up, adjusting and clamping casting, rough boring, finishing, counterboring and facing both ends of one (1) chamber to blue-print. Casting unclamped and on floor. Per casting:

1—Classes, all slide valve engines. *Time.*

a Cylinders under 24 inches..........................00.0

b " 24 inches and over.....................00.0

ABOVE AND ON THE NEXT PAGE ARE SAMPLES OF STANDARD EFFICIENCY SHOP SCHEDULES AS APPLIED IN THE SHOPS OF A LARGE RAILWAY SYSTEM. THESE SCHEDULES COVER SOME 23,000 OPERATIONS, WITH OVER 5000 SKETCHES TO ILLUSTRATE SAME. THIS PROVIDES AN ACCURATE CHECK ON THE COST OF PRODUCTION OF EACH SHOP, AND IS THE MEANS OF KEEPING DOWN REPAIR COSTS TO A MINIMUM FIGURE. THE SAMPLE CYLINDER-ERECTING SCHEDULES GIVEN ON FOLLOWING PAGE ILLUSTRATE THE COMPREHENSIVE AND PRACTICAL ARRANGEMENT OF THE STANDARD SCHEDULES.

Cylinders.

1A0–1 APPLYING 2, COMPLETE. RATE, —

Applying one pair of two (2) new cylinder castings to an engine in the erecting shop. Includes laying-off connecting bolt holes on cylinder halves; drilling, counterboring, and reaming connection bolt holes, driving bolts, and bolting halves together; laying-off saddle for chipping, chipping saddle to fit smoke arch; level and line boiler and frames; drilling and reaming saddle-bolt holes, driving saddle bolts, and bolting cylinders to smoke arch; reaming all cylinder frame bolt holes, drilling holes when necessary, and driving all bolts; fitting and driving frame keys; lay off and grind in back cylinder and valve heads, applying all cylinder and valve head studs, bolting up back heads; cleaning out ports, steam passages and cylinders and blowing out with steam or air.

	Time.
1. Classes 31 to 34; 36 to 38, incl. (single frame)	00.0
2. " 41 to 45; 47 to 49, incl. (double frame)	00.0
3. " 51 to 54; 56, 57, 58, 59	00.0
4. " 61, 62, 64, 68	00.0
5. " 71, 74, 76	00.0
6. " 81, 82, 83, 84, 85, 86, 87, 88	00.0

Bolts—Connection.

1A9–1 REAMED. RATE, —

Reaming connection bolt holes through cylinder castings, bolted together temporarily, complete for applying connection bolts. Per bolt:

	Time.
1. All Classes.	
a With ratchet	00.0
b With air motor	00.0

Gland—Exhaust.

1A37–1 LAYOUT. RATE, —

Layout for drill and boring one (1) new L. P. exhaust gland. Per gland:

	Time.
1. Classes 56, 68, 92	00.0

Head—Back Cylinder.

1A39–3 GROUND IN—NEW WORK. RATE, —

Grinding joint on one (1) new back cylinder head, when casting is on floor. Per head:

	Time.
1. All Classes, cylinders under 24 inches.	
a With air motor	00.0
b By hand	00.0
2. All Classes, cylinders 24 inches and above.	
c With air motor	00.0
d By hand	00.0

Valves—By-Pass.

1A55–1 JOB COMPLETE. RATE, —

Grinding in one (1) by-pass valve and one (1) joint ring, applying studs, put up valve chamber and bolt down complete. Per valve:

	Time.
1. Classes 41, 42, 57, 58, 59, 61, 72	00.0

normal, doing only one-third of what they should have done. These figures are not guessed at, but taken from the actual operations of this large locomotive repair shop, in which every job is standardized and the efficiency of every man determined. Now, the system is perfected and it costs no more to keep it in operation than the former barren methods."

The successive steps of progress were:

1. A permanent and standard method for determining costs of every operation.
2. The betterment of all conditions.
3. The determination of a standard cost of every operation.
4. A comparison of actual costs with standard costs as to every operation.
5. The guarantee to each individual worker of standard wages, and the payment of an added amount, based not on the piece or on output, but on efficiency.
6. A check and reward of each foreman on the basis of the efficiency of those under him.
7. A check of efficiency of the shop as a whole from month to month.
8. The use in all accounting, of standard costs, not accidental actual costs.

A brief outline of the successive steps follows:

"Costs are of two kinds, those that can be located and those that cannot be located. The work of a machinist and also of his machine can be located. The problem of cost determination reduces itself into apportioning to each man and each machine, the indirect or unlocated costs in addition to the direct or located costs. To do this, each item of indirect cost is apportioned either to men or to machines or partly to one and partly to the other. Having thus secured two grand totals, one of indirect men costs and the other of machine costs, the totals are subdivided to various departments. Whereas the indirect cost as a whole may be 75 per cent of the pay-roll, within the confines of a department, the percentage may vary from 15 per cent up to 400 per cent, showing how absolutely inaccurate the usual method is of applying the same flat rate of factor, surcharge or burden to all departments alike.

"Having secured substantial accuracy by apportioning each class of costs, men-costs and machine-costs, to each department, no great errors can arise in any particular method of subdividing departmental charges to specific men and machines. The simplest method is therefore preferable. The method adopted at Topeka was to assess indirect men-costs as a percentage on applied labor, to assess all direct and indirect machine-costs as a yearly charge on the inventory value of the machines. To ascertain the hourly rate for each machine, the yearly charge to the machine was divided by 2,400 hours, it being assumed that the machine worked 80 per cent of the time. If there were any gains in simplicity to be effected by modifying this general method within the boundaries of a department there was no hesitation in allowing common-sense to govern. For instance, when it was discovered that a direct worker on a machine did 200 different small jobs a day, he was at once considered an indirect worker, and when a machine rate worked out at $0.01 an hour, the machine was promptly relegated to the list of indirect machines. There is no sense in an accuracy that makes the distribution of cost amount to more than the cost itself.

"Power is determined at so much per horse-power and floor space at so much per square foot for the plant as a whole and charged on a flat basis to each department. If one department is further from the power-house than another and therefore suffers a greater line-drop loss, this loss is considered a plant loss, and a department loss, and it is borne in the form of a general increase in power cost. What would one think of a gas or water company which charged more for gas or water because the customer was farther from the central plant, or which charged repairs of mains to the customers served by the mains? Yet just this kind of

cost accounting has brought the whole art of factory cost accounting into deserved disrepute!

"With a machine rate, man rate, and man surcharge provided, and time known, the cost of every operation is at once determinable.

"The betterment of all conditions was a very large task, and involved everything that could be done to improve machines, tools, operation, and general comfort of the men; as, for instance, better lighting and heating. It is evident that standard costs could not be determined until conditions were in the main standardized

"The determination of standard costs was most completely and conscientiously carried out. The motto adopted and promulgated by the authorities in a pamphlet distributed to the men was:

'Fairness, not Favoritism.
Individuality, not Subserviency.
Efficiency, not Drudgery.'

"A time study of a job under actual working conditions by the regular worker was made by a practical man, a machinist, a boiler-maker, or a blacksmith, as the case might be. The machines and other conditions, tools, belting, speed, etc., were first adjusted. It makes no difference whether the job under observation actually took a long or a short time. It was the duty of the observer to set down a reasonable and proper time. As a rule the times eliminated from standard were not those of reasonable work, but those of unnecessary waste.

"The comparison of actual costs with standard costs as to every operation is exceedingly easy. Each job is assigned to each man on a work-card which states the standard time. The man notes his own actual time, which in the aggregate must check with his clock time. The efficiency of each man is tabulated each month, and the efficiency reward is on a sliding scale. It begins at 67 per cent and increases rapidly according to a table carried out to tenths of a per cent.

"The efficiency of the foreman depends on the efficiency of all the men under him. If all the men average 100 per cent the foreman receives 20 per cent increase on his own wages. Under some other foreman the extra earnings of the men might be in the aggregate more, but not average as well, if some men were very good and others very poor. Such a foreman would earn less increase, so it is to the advantage of a foreman to bring up his whole force evenly."

Mr. Emerson shows two diagrams of monthly records of shop efficiency, the abscissæ of the points on the curves representing percentages of efficiency, and the ordinates, percentages of time worked at the efficiencies shown. On these a vertical line shows the average efficiency for the month. Commenting on these records, Mr. Emerson says:

"Shop efficiency as a whole is determined by the average efficiency of all the workers. The two diagrams show the same shop in two successive months, and the improvement in the second month is largely due to the lessons in the diagram of the first month. It is plain that the shop is improving when the average efficiency line moves to the right, that it is retrograding when it moves to the left. It can be made to move to the right by finding out what the matter is with the men whose average efficiency is low, and all workers with an efficiency under 70 per cent should be investigated. The record is there not only as to monthly efficiency, as a whole, but as to every single job done in the month. It often happens that efficiency falls through no fault of the worker, as when a steel casting is so hard as to make normal work impossible. In very marked cases of this kind, temporary schedules are put into effect to suit the peculiar and exceptional occurrence.

"Since every job is standardized, it necessarily has a standard cost. How ridiculous it would be for a railroad company to attempt to vary its ticket prices on account of accidental delays or extraordinary expenses, as for a wreck.

"It is not less ridiculous to attempt to follow into cost accidental variations of shop operation. If a fast worker is on a job one day and a slow worker on the

same job the next day, both have varied from standard, but the selling price of what they have made has not changed.

"Variations from standard costs are accidents of shop operation, and are to be taken care of, not in detail but as a whole, by a factor added in the office. In the examples of the two months, the efficiency of labor was 89.5 in March. Actual labor costs were therefore 11.7 per cent, and could have been applied to each item of the output in the following month. In April the actual costs were 6.2 above standard, so for May 6.2 per cent could have been added to the direct labor part. The discrepancies should, however, be averaged for at least twelve months, and if this were done it would be found that the fluctuation in office factor to be thrown forward with the succeeding month would not vary as much as 1 per cent from month to month.

"The effects of this system of shop management are:

"(1) To increase output enormously without adding to shop equipment or space.

"(2) To reduce unit costs as much as 30 per cent or more.

"(3) To increase the pay of the best men as much as 30 per cent on the average.

"(4) To hold permanently the best men.

"(5) To know accurately the cost of every item before work is begun on it.

"The system is equally applicable to railroad operations as a whole, *i. e.*, the mileage of engines and cars and tonnage movement. It is, in fact, on the Santa Fe now being adopted to determine the efficiency of each engine, exactly as in the Topeka shop it has been perfected to determine the efficiency of each man. Even as men in average shops work with less than 60 per cent efficiency, so also do engines work with less than the 60 per cent efficiency. What was done with the men in the shop can be done with engines."

GENERAL TOOL SYSTEM.

Atchison, Topeka & Santa Fe Railway.

PREVIOUS issues of this journal have called special attention to the comprehensive betterment work undertaken in the motive power department of the Santa Fe. This work was inaugurated early in 1904, at a time of labor difficulties and upon completion of one of the largest locomotive repair shops in the country, at Topeka. At the same time the managing officers undertook to make adequate provision for an immensely increasing traffic, that was clearly foreseen, by the acquisition of a large number of the most modern and very heavy locomotives for both passenger and freight service.

Object of Betterment Work.

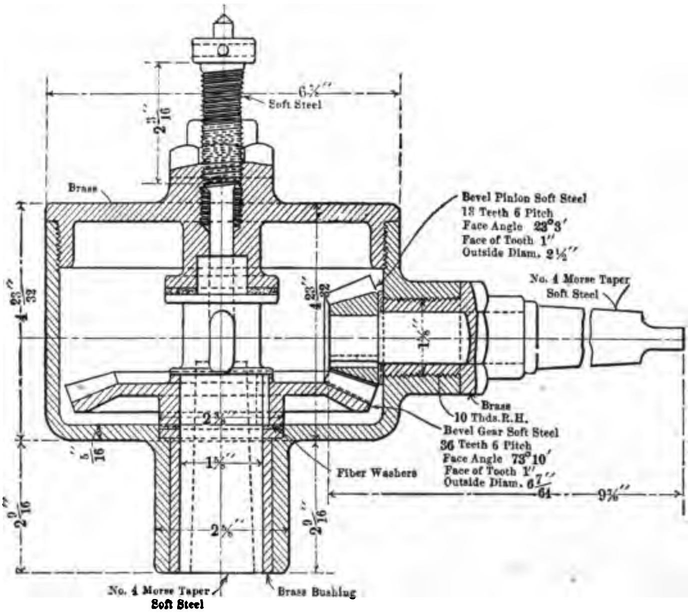
In undertaking the betterment work it was the desire of the management to use this motive power to the best advantage and at the same time to keep the repair costs of these large and new types of engines within a reasonable figure. Most of the locomotives were compounds, many of them of the balanced type. In order to adequately take care of the shopping of these engines, and to carry out thoroughly a system of standardization of locomotive parts, centrally manufactured at the Topeka shops, it was realized that the tool and machinery equipments of the shops and the methods of doing the work must be the very best. For this reason special attention was directed to the tool and machinery problem at the beginning of the betterment work, an attention which has been consistently followed up to the present time.

While the technical journals have made some mention of this phase of the work, its importance as the keystone in the arch of betterment and economy for the production of efficiency has, perhaps, been lost sight of in the more extensive mention that has been made of matters of greater magnitude in the gross amount of costs involved.

Outline of Tool System.

The purpose of this article is to consider the details of this remarkably successful application of commercial tool methods to railway shop practice. The plan of this supervision comprised:

First. The use of tools that would foster the wholesale production of standard locomotive and car parts at the central shop.



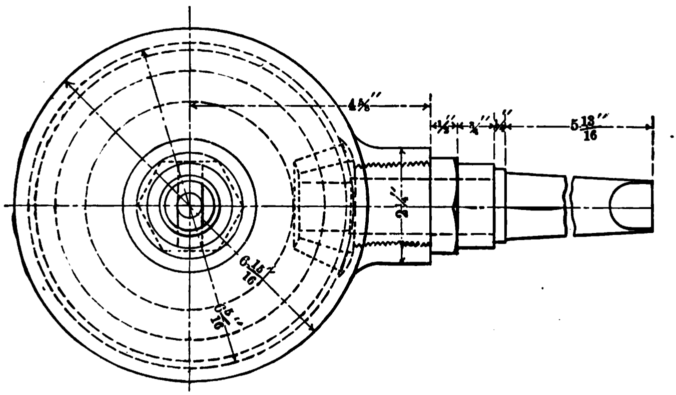


Fig. 112—Angle device for drilling and reaming in close quarters. Three sizes are made, the illustration showing the largest.

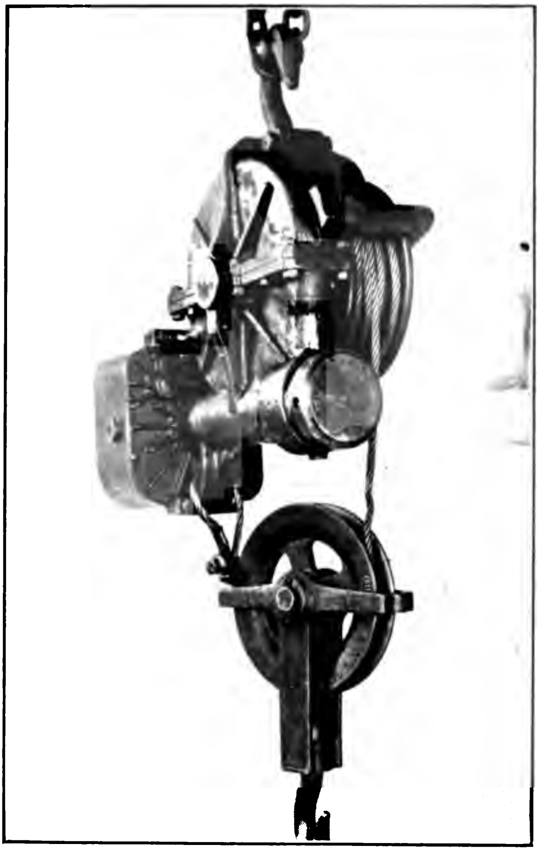


FIG. 113—STANDARD MOTOR BLOCK AND TACKLE, DESIGNED AND BUILT IN TOPEKA TOOL-ROOM. AN EXAMPLE OF CAPACITY FOR REFINED MANUFACTURE.

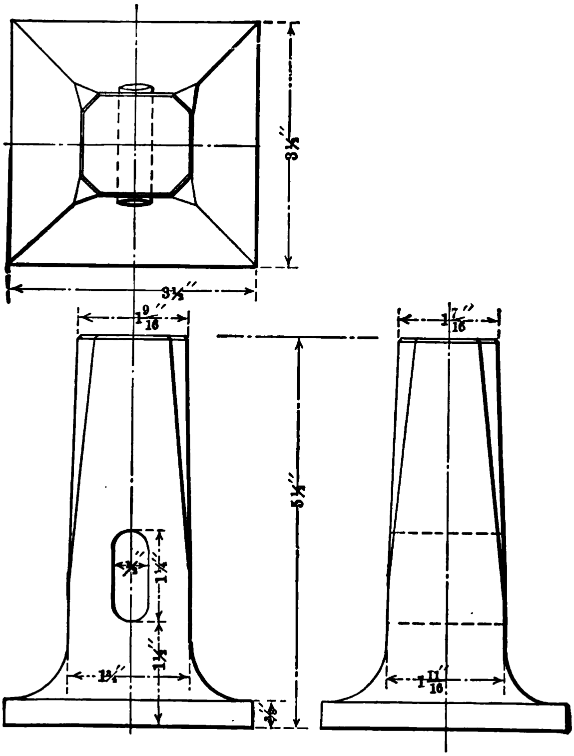
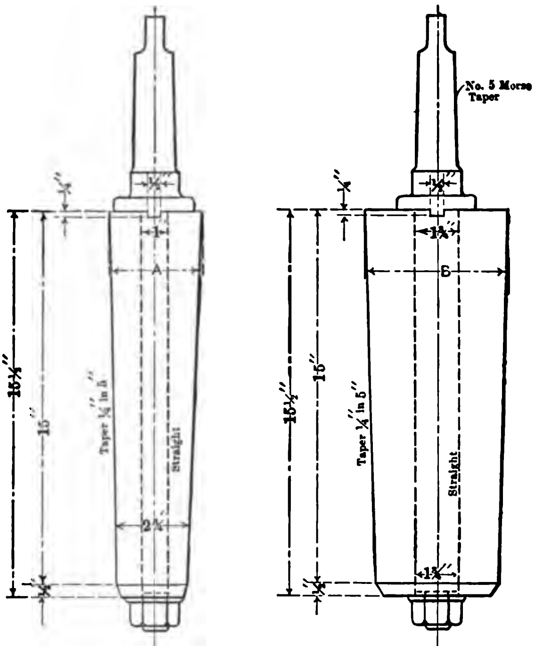


Fig. 114—Standard blacksmith flatter. An example of economical tool manufacture by drop forge. Dies and method devised by an agressive shop superintendent and his ingenious blacksmith foreman. Net labor and material cost, 13 cents.



A = 2¾, 3⅛, 3½'' B = 3⅞, 4¼, 4⅝, 5, 5⅜, 5¾''

Note: All Reamers Fluted with Left Hand Spirals
62'' Pitch and Cutting Faces Radial

FIG. 115—STANDARD CROSSHEAD AND PISTON REAMERS. THERE ARE NINE SIZES IN ALL, WITH DIAMETERS VARYING BY THREE-EIGHTHS OF AN INCH. THE THREE SMALLER SIZES ARE MOUNTED ON 1-INCH ARBORS, AND THE SIX LARGER SIZES ON 1¾-INCH ARBORS. ALL OTHER DIMENSIONS ARE UNIFORM.

SECOND. The development and application of special tools, jigs, devices and facilities that would lighten the labor of the men and increase their output capacity, thus acting as an almost inseparable adjunct to the introduction of an individual effort system of reward.

THIRD. The betterment of machines, including motors, shafting, pulleys, etc.

FOURTH. To effect simultaneously with these results an economy in the excessive expenditures for tools of all kinds, by eliminating waste, introducing more durable and serviceable types, and avoiding undesirable investments.

FIFTH. The close and detail supervision of tools, machines and methods in railroad work, as it is found by Fred W. Taylor to be, in commercial work, an indispensable factor of shop betterment and individual labor reward; it is, moreover, possible to effect many cost reductions by the methods alone, irrespective of the labor stimulus, as in the case of cylinder and eccentric drilling jigs and other jigs.

This involved the development and manufacture of many classes of tools as indicated in the following synopsis:

1.—General tools and devices for use generally over a large part of the work and in almost all shops, including:

a Three sizes of bevel gear angle device for getting into restricted quarters with an air motor. See Fig. 112.
b High-speed flat drill chucks, No. 5 Morse taper shank.
c Knuckle joint reamers.
d Universal joints for reaming in restricted quarters.
e Standard punches, stocks and couplings.
f Standard worm-driven air hoist. Fig. 113.
g Standard blacksmith tools. Illustrated by flatter shown in Fig. 114.
h Standard rivet snaps.
i Standard high-speed lathe, planer and boring tools.
k Various standard taper reamers for erecting work, such as:

Standard taper reamers for blade pins used on all standard classes of engines, thus making it possible to manufacture blade pins on an automatic machine.

Standard taper knuckle-joint pin reamers used on all classes of engines, reducing the number of reamers in each shop to only four.

Standard taper link motion pin reamers. Standardizing the taper on all link motion pins of all engines will not only reduce the number of reamers at each point to a minimum, but will make it possible to concentrate the manufacture of pins at a central point, supplying all outside points on requisitions.

Standard crosshead reamers. The taper on piston, crosshead, and wrist pin fits was standardized for all classes of engines on the system, reducing the number of reamers to only nine, as shown in Fig. 115.

Standard reamers for reaming frame holes to standard sizes, making it possible to concentrate the manufacture of finished engine bolts for the system at Topeka, thus using the automatic bolt machine to its full capacity.

Besides these, nine special standard ball-joint reamers, with inserted blades diametrically opposed but unevenly spaced, were shipped to the principal points on the system in order that a standard radius might be made on all steam pipes on engines passing through the shops.

2.—Special devices, such as mandrels and chucks, to facilitate the machining of various classes of work.

3.—Jigs—attachments to machines for the economical production of various kinds of work.

4.—Templets and jigs, to obviate the necessity of laying out work. Includes jigs and templets for:

a Drilling steam-chest stud holes.
b Drilling cylinder stud holes.
c Drilling cylinder saddles, cylinder heads, valve-chamber heads, spiders, follower plates, eccentric straps, steam-pipe elbows, packing glands.
d Laying off driving-box brasses.
e Drilling flue-roller casings.

5.—Special machines:

a Centering machine.
b Snap ring packing ring milling machine.
c Crank axle pin turning machine.
d Complete reconstruction of cylinder boring machine, as shown in Fig. 116.

6.—Machine improvements:

a Speeding up line and countershafts.
b Pulleys enlarged.
c Wider driving cones applied.
d Larger feed cones and gears.
e Use of bronze worms.
f Steel gears and pinions.
g Increase in size of motors for motor drives.
h Standard abrasive wheel stands. Fig. 117

7.—High speed milling cutters and gang cutters:

a For heavy production work on shoes and wedges.
b Cutters with inserted teeth for side-rod channels, eccentrics, eccentric straps, etc.
c For small accurate work on flanging dies, MCB tire and knuckle gauges, tire finishing tools.

The general tool-room at Topeka is equipped to handle tool work of every description, having all the facilities and labor-saving devices and methods that have proven really efficient. Examples of lessened costs of production under the new system, with improved quality of output, may be given.

Reduced Production Costs.

FIG. 116—IMPROVED CYLINDER BORING MACHINE ENTIRELY RECONSTRUCTED IN RAILROAD SHOP AND TOOL-ROOM. THIS IS AN EXAMPLE OF THE FACILITY WITH WHICH EVEN LARGE SPECIAL MACHINES MAY BE PRODUCED BY A THOROUGHLY ARRANGED AND EQUIPPED TOOL-ROOM AND FORCE. THIS MACHINE WILL BORE, FACE AND FINISH COMPLETE AN 18-INCH SINGLE CYLINDER IN FROM TWO TO THREE HOURS, WHICH IS EQUAL TO THE PERFORMANCE OF ANY COMMERCIAL TOOL.

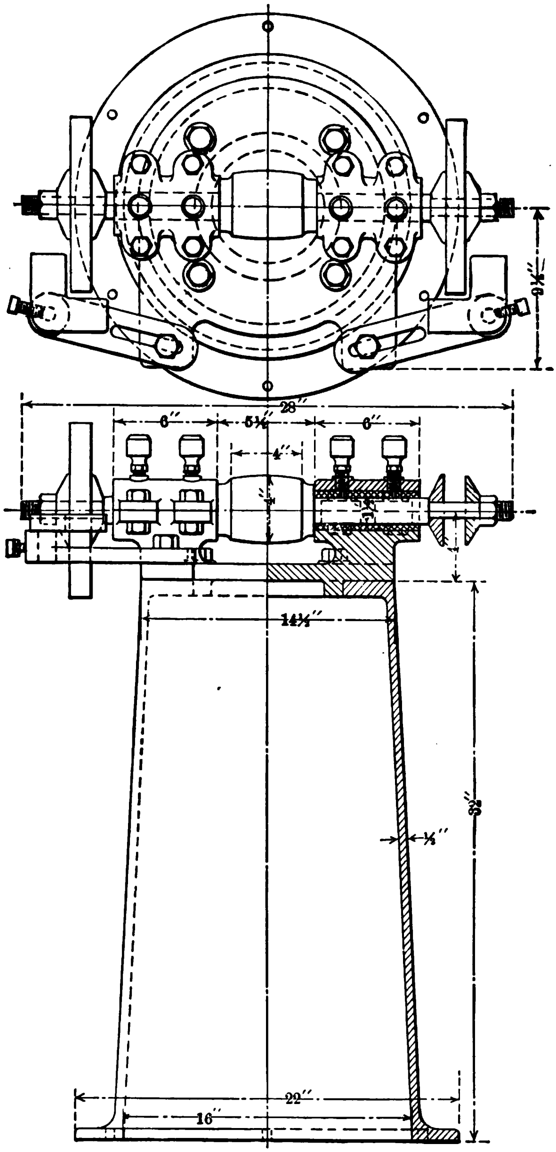


FIG. 117.—STANDARD ABRASIVE WHEEL STANDS FINISHED IN TOOL-ROOM AT TOPEKA, AND IN GENERAL USE IN ALL SHOPS ON THE SYSTEM.

FIG. 118—TOOL-HARDENING ROOM AT TOPEKA SHOPS. HERE, ALL THE CUTTING TOOLS MANUFACTURED IN THE TOOL-ROOM ARE TEMPERED OR HARDENED.

(Form 1077 Standard)

STOCK BOOK____________________

Section________

Catalogue Page.....	DESCRIPTION OF ARTICLES	Symbol Number	Units of	JUNE		JULY		AUGUST		SEPTEMBER	
				Inventory	Ordered	On Hand	Ordered	On Hand	Ordered	On Hand	Ordered

FIG. 119—UPPER PART OF ONE PAGE OF TOOL-STOCK BOOK IN WHICH EACH SHOP KEEPS A RECORD OF TOOLS ON HAND AND ON ORDER. RECORDS FROM JUNE TO SEPTEMBER ARE CARRIED ON THIS PAGE AND THE REMAINING EIGHT MONTHS ON PAGE OPPOSITE.

Turning flue-roller pins, former day's output, 8 in 10 hours; present output, 46 in 10 hours.

Milling a $28\frac{1}{2}''$ reamer, complete, former time, 7 hours; present time, 3.2 hours.

Forging blacksmith flatter under steam hammer, former cost, 24c.; present cost, 13c.

Another new departure in railroad practice is shown in Fig. 118; this is a special tool-hardening room equipped with a gas furnace and annealing ovens, water, oil and air baths, and all facilities for the production of perfect tools without failure. The temperatures for exactly uniform product are determined by an electric pyrometer, and not by color, thus eliminating all chance of error. This room is adjacent to the manufacturing tool-room and the work is directly under the supervision of the general tool foreman.

Tool-Hardening Methods.

The general storehouse stock of standard tools is an indication of the economy and advantage incident to the policy of centralized standard duplicate manufacture of railway tools, instead of the general practice of each local shop manufacturing individually from individual varying and special designs. Under the new policy not only are the tools more perfectly designed and built, and more cheaply, but the needs of all shops are served more promptly and efficiently by the finished stock at the general storehouse, a stock which is much smaller than would be needed, were each local shop to protect its own requirements.

Standard Tools in Stock.

The foregoing covers in a general way the mechanical features of the tool system, as carried out in successful practice. In order to make the system effective, and maintain an efficient but minimum stock of tools at all shops, a tool-stock book is provided. The sample page of this book, illustrated in Fig. 119, shows the arrangement of columns for keeping a record of tools on hand and on order, by months. The book is ruled so that a double page contains the record for a fiscal year, thus providing a perpetual inventory.

Tool Stock Book.

On the first of each month all books are sent to Topeka, along with the monthly requisition for the tools required. The books are then checked up with the requisition and immediately returned. Requisitions for tools are made once each month. A direct supervision over each tool-room of the system is thus obtained and the maintenance of the tool-room equipment is not left to the individual judgment of each tool-room foreman. This method has not only kept down the stock of

tools to a minimum, but greatly increased the efficiency of every tool-room on the system.

The methods, organization and details of operation of the tool system have been covered in a bulletin issued by the assistant superintendent of motive power. This bulletin is posted in all shops of the system for the instruction of both foremen and workmen. By this means all concerned are made familiar with the rules and regulations of the tool system, and the coöperation which naturally follows has greatly increased the efficiency of tools and tool-rooms. The bulletin referred to is as follows:

Tool Regulations.

TOOL REGULATIONS.

Proper and economical work depends upon the tools used, the condition in which they are kept, and their availability for service when needed. System must be used in the care and distribution of tools, so that excessive amounts of them will not be accumulated, and so that expensive tools will not be kept idle in one place when they are needed in another; system must be used in the standard design of tools and methods of doing work adopted, so that the work may be properly and economically done.

With these objects in view, all decisions as to designs of tools, jigs, special devices, etc., and as to methods of doing work, will be made after reference through the office of Assistant Superintendent Motive Power, at Topeka; all suggestions as to changes in methods and all ideas as to changes in design of tools, devices, etc., or as to new forms of tools or new jigs and devices, must be submitted to that office in duplicate, and receive the approval of the Assistant Superintendent Motive Power, before they can be put into effect or be adopted. This is necessary, as often ideas and methods are developed at considerable expense in one place, when they have been already tried and proven unsatisfactory elsewhere. This useless expense should be avoided. Recommendations may be made either through the regular channels, or directly by the men.

A system for checking tools out from the tool-room, checking them up in the tool-room, and inspecting them while out of the tool-room, has been developed from the best practice in use at first-class shops, and will be thoroughly installed in all tool-rooms on this system.

This tool system will comprise the following features:

A. Perpetual or continuous inventory will be had of all tools, machines, and devices of all sorts at each shop, showing location of tool, whether assigned to tool-room stock or to the permanent use of an individual man or gang.

B. Uniform aluminum checks of special design, six to each man, will be furnished from Topeka for each shop, indicating the shop and the block number of the mechanic to whom issued; these checks will be issued only to such men as require to call on the tool-room for tools; Topeka will be called on for such checks as are required from time to time, which will be forwarded by railroad mail.

Hall-8-08-10M-2628 (Form 2028 Standard.)

Santa Fe.

IN ALL-CASES WHERE TOOLS ARE LOST, BROKEN OR DAMAGED, THIS CARD MUST BE FILLED OUT.

TOOL BREAKAGE CLEARANCE.

(ONLY ONE TOOL TO EACH CARD.)

No. .... has — Check Here: ....*Worn Out* / ....*Damaged* / ....*Broken* / ....*Lost*

(SHOP LETTER, NUMBER AND NAME.)

.... size ....

(GIVE FULL NAME OF TOOL.)

as a result of — ....*Defective Material* / ....*Accident* / ....*Ignorance* / ....*Carelessness*

O. K.

This card must be signed by your Foreman, one of the following:

INITIALS HERE.	DATE
GANG FOREMAN.	
TOOL KEEPER.	
GEN'L TOOL FOREMAN.	
GEN'L FOREMAN.	

FIG. 120—TOOL BREAKAGE CLEARANCE CARD. WHEN A TOOL IS LOST OR BROKEN, A CLEARANCE CARD PROPERLY SIGNED MUST BE PRESENTED AT THE TOOL-ROOM BY WORKMAN TO OBTAIN HIS CHECK ON TOOL.

Form 2033 Standard

Santa Fe

(Insert name of Railway Company.)

REPAIRS AND RENEWALS TO SHOP MACHINERY AND TOOLS: Account 47. (Replacing Old Account 17.)
AND CHARGES TO POWER PLANTS, EXCEPT ENGINES, BOILERS AND MACHINERY CHARGEABLE TO OTHER ACCOUNTS.

AT .... *SHOPS, DURING* .... 190.....

	SHOPS		Renewals large machinery in Replacement of Old and charged to Account 47 0	Repairs and Renewals to Machinery Appliances, shafting, etc., except as otherwise designated on this form. 1	Making New Tools for use with Machines 2	Repairs to Tools for use with Machines, including Dressing 3	Repairs and Renewals of Power Engines and Boilers in Shops, etc 4	Repairs and Renewals to Air Line and Air Tools 5	Repairs and Renewals of Abrasive Wheels 6	Repairs and Renewals of Belts 7	Repairs to Electrical Machinery, including Cranes 8	Other than Foregoing * 9	TOTAL
47-A	*Machine,*	11											
47-B	*Erecting Shop,*	12											
47-C	*Boiler Shop,*	13											
47-D	*Blacksmith Shop,*	14											
47-E	*Tin Shop,*	15											
47-F	*Brass and Air Room,*	16											
47-G	*Tool Room,*	17											
47-H	*Water Service,*	18											
47-I	*Pattern Shop,*	19											
47-K	*Car Machine Shop,*	20											
47-L	*Loco. Carpt. Shop,*	21											
47-M	*Wheel and Axle Shop,*	22											
47-N	*Power Plant,*	23											
47-O	*Miscellaneous,*	24											
	TOTAL,												

This account includes REPAIRS:
Cost of material used and labor expended in repairing tools and machinery in engine houses and at locomotive and car shops and foundries:
Column No.
(4) Including stationary engines and boilers for furnishing power.
(1) Scaffolding and shafting.
(7) Belting
(1) Other appliances for running machinery, cranes, hoists, power and hand (except electrical), drop tables, jacks and other appliances used in connection therewith; also in repairing furnaces, forges, hydraulic and other portable jacks.
Portable scales and sewing machines used in shops. Cost of repairing heating boilers should be charged to account 16, "Buildings, Fixtures and Grounds."

RENEWALS. Cost of new tools: (1, 2 and 5).
Column No.
(0) Machinery (less salvage), used in engine houses and at locomotive and car shops and foundries
(4) Including stationary engines and boilers for furnishing power
(1) Scaffolds and shafting
(7) Belting
(1) Other appliances for running machines.
(0) Cranes.
(1) Hoists (power and hand).
(0) Drop tables
(1) Jacks and other appliances used in connection therewith.
(0) Furnaces and forges
(1) Hydraulic and other portable jacks. Portable scales and sewing machines used in shops.
Cost of renewing heating boilers should be charged to account 16, "Buildings, Fixtures and Grounds."
*NOTE.—Give explanation on separate sheet of each individual item constituting charges in this column.

Date ....

Storekeeper .... Motive Power Accountant.

FIG. 121—FORM FOR KEEPING CHARGES OF REPAIRS AND RENEWALS TO SHOP MACHINERY AND TOOLS. THIS FORM IS MADE OUT AT EACH SHOP EVERY MONTH, AND SHOWS THE VARIOUS CHARGES TO THE TOOL ACCOUNT.

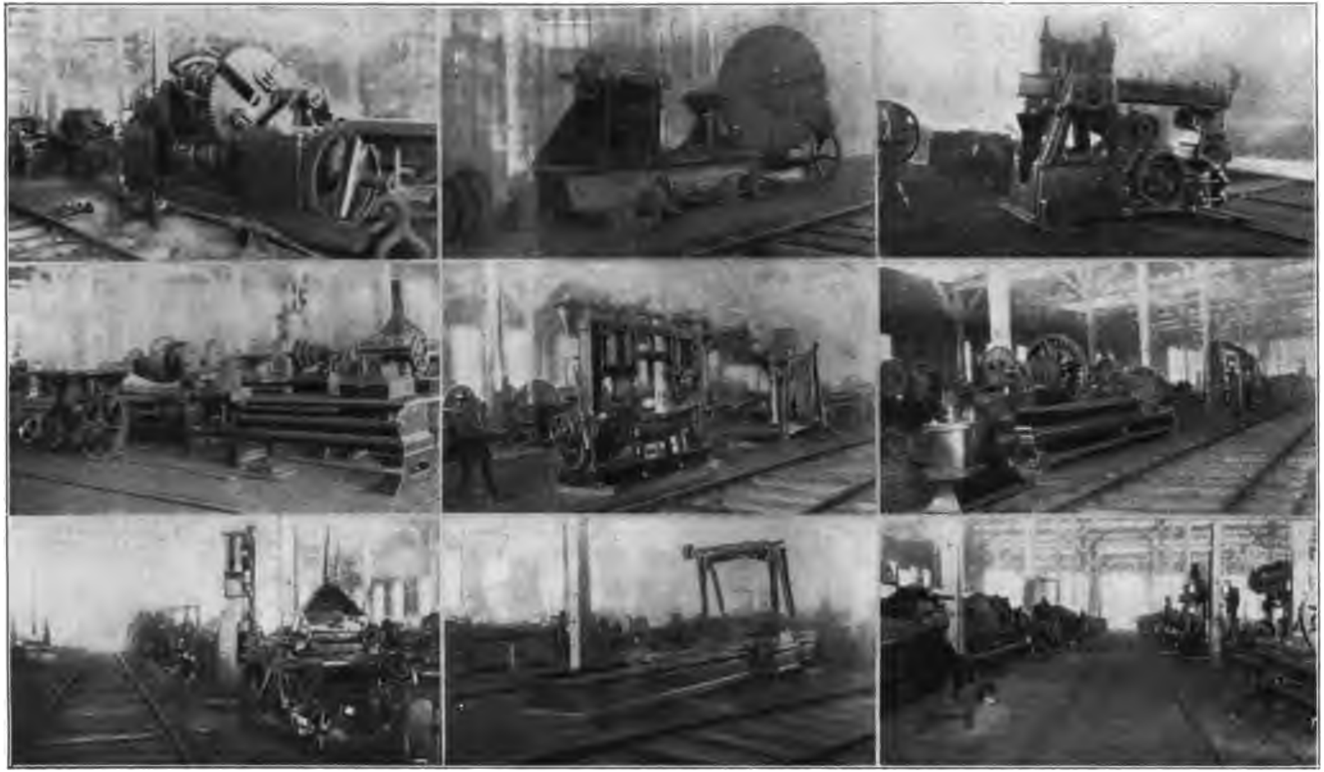


FIG. 122—SUPERVISION OF RAILWAY TOOLS AND MACHINERY IS NOT CONFINED TO ECONOMIZING ON CURRENT MAINTENANCE EXPENDITURES, BUT IN MODERNIZING THE METHODS UPON COMMERCIAL PRODUCTION LINES IS ABLE TO BRING ABOUT MUCH LARGER COST REDUCTIONS BY CONCENTRATION OF MANUFACTURE OF FINISHED PARTS AT A CENTRAL SHOP. THE RESULT OF THIS POLICY IS TO MAKE MUCH OF THE MACHINE EQUIPMENT OF SMALL AND OUTSIDE SHOPS UNNECESSARY. ABOVE ARE PHOTOGRAPHS OF A FEW TYPICAL MACHINES OUT OF THE LARGE NUMBER BEING CONSTANTLY BROUGHT IN TO THE GENERAL STOCK WHERE THEY MAY BE HELD AVAILABLE FOR EQUIPPING FUTURE EXTENSIONS OF MAIN SHOPS, OR OF NEW LINES, WITHOUT ADDITIONAL CAPITAL INVESTMENT.

FIG. 123—IN ADDITION TO LARGE TOOLS AND MACHINERY THAT ARE FOUND TO BE SURPLUS UPON CHECKING UP THE INVENTORY OF ALL SHOPS AND ROUNDHOUSES COMPLETELY, AND RE-APPORTIONING MUCH OF THE WORK REQUIRED TO BE DONE FROM SUCH SHOPS TO THE MAIN SHOPS, MANY SMALL TOOLS CAN ALSO BE RETURNED TO GENERAL STOCK SO AS TO BE SUBJECT TO USE WHERE NEEDED, RATHER THAN TO ACCUMULATE AS EXCESS LOCAL RESERVE. THIS PHOTOGRAPH ILLUSTRATES SUCH A SURPLUS OBTAINED FROM A FEW DIVISIONS.

C. Standard tool-lockers will be assigned to men using tools as far as practicable.

D. Standard tool-kits for each class of occupation will be determined upon and these kits will be supplied to each man when he enters the service, he signing up for same and being held responsible therefor; the man will also be held responsible for the checks issued.

E. A regular weekly inspection system of all tools will be inaugurated as rapidly as it can be organized.

In addition to these general measures, the following special regulations will be in force:

1. No tools will be issued from tool-room except for tool-check.
2. No new hand-hammers or monkey-wrenches to be given in exchange for old ones unless accompanied by an order from the gang foreman and marked "OK" by shop foreman; chisels and soft hammers to be the only tools exchanged for new ones without a written order.
3. No letters or figures to be given out in lots of less than a full set.
4. All tools out on check must be turned into the tool-room every Saturday night before the tool-keeper leaves the shop. In all cases where tool-checks remain on the board over Sunday, the tool-keeper should notify the tool-room foreman or the general foreman, and the men whom these checks belong to should be required to give an explanation for not returning the tools. In some shops it may be desirable to check up the tools daily.
5. In all cases of broken, or lost, or damaged tools, the tool-check will not be returned until the tool clearance card (Fig. 120) has been personally signed by the general foreman as per circular letter No. 358.
6. In places where, in addition to tools, the tool-room is used for a sort of shop sub-store for small engine supplies, such as cutters, small bolts, etc., the gang foreman's orders will be honored for these supplies.
7. The custody of all high-speed lathe, planer, and boring-mill tools should come under the tool-room foreman, or the man in charge of the tool-room. A man starting to work on a machine requiring these tools should be given a set, and these should be charged to him. Should he break one of these tools, he will exchange it for a new one in the tool-room. The tool-room foreman or the tool-man should get a list of the number of high-speed tools, the list showing size and style now at various machines, and the workmen should sign up for them.
8. All air motors must be returned to the tool-room every Saturday night and be thoroughly inspected and oiled before leaving the tool-room again. At shops like Topeka, Albuquerque, San Bernardino and Cleburne, it may be desirable to assign certain motors to a gang, and that this gang be allowed to use these motors during the week, turning them into the tool-room on Saturday night for regular inspection. All motors should be numbered and a record kept of what gang they have been assigned to. Where parts of motors are missing, the motors should not be accepted without authority of the tool-room foreman. It should be the tool-room foreman's duty to see

that all motors are regularly inspected and repaired and oiled as often as necessary, which, for motors in service, should be as often as once a week.

While the efficiency of tools and tool-rooms is of primary importance, expenditures for expensive tools and devices are not approved unless there is a direct need for them and the saving in production costs is represented by a satisfactory return on the investment. In order to keep an accurate record of the charges to repairs and renewals to shop machinery and tools, the form shown in Fig. 121 was adopted. The form is arranged with nine columns, each reserved for a different charge account covering repairs and renewals to shop machinery and tools, and charges to power plants. This form is filled in once each month at all shops and forwarded to Topeka. An accurate check and supervision over the tool account is thus obtained and excessive expenditures for tools are eliminated without impairing the efficiency of the tool system.—*American Engineer and Railroad Journal, June, 1908.*

Record Form for Tool Repairs.

RAILROAD SHOP TOOL-ROOMS.

EDITORIAL COMMENT BY AMERICAN ENGINEER AND RAILROAD JOURNAL, JUNE, 1908.

The best trained and equipped army in the world would be seriously handicapped if supplied with poor ammunition. The tool-room in the railway shop corresponds to the ammunition for an army. One of the most efficient and best managed railroad shop tool-rooms is at the Topeka shops of the Santa Fe. The small tools for the entire system are designed and manufactured there, and a tool department, under the direction of the assistant superintendent of motive power, not only has this in charge, but also looks after the supply, use and maintenance of all the small tools and machine-tool equipment on the system. Probably no other railroad has given as much care and attention to this subject. The general features of this tool system are considered on page 239 of this issue of the *Journal.*

LOCOMOTIVE REPAIR COSTS.

COMPARISONS between costs of locomotive repairs on different railroads are valuable only as they reflect the general tendencies from year to year rather than the existing differences in cost.

The cost of locomotive repairs is influenced by a number of factors, namely: (1) Size of locomotive, (2) cost of labor, (3) cost of material. (4) operating conditions, (5) shop methods and facilities. All of these factors bear an intimate relation to locomotive repair costs and each must be considered when making cost comparisons either from year to year on the same road or between reports of separate companies.

General Considerations.

A close investigation of conditions is always necessary before accepting cost figures as statements of real facts, or as a mirror reflecting the true elements that contribute to the results shown. This is especially true when comparing costs of locomotive repairs on the Santa Fe for the past few years, as the figures given in no way indicate the higher efficiency maintained in locomotive repairs as compared with five years ago.

The annual reports of the road for recent years give the cost of locomotive repairs in cents per engine-mile as follows: 1903, 8.67 cents; 1904, 11.34; 1905, 12.56; 1906, 9.54; 1907, 9.40. It will be observed that the cost of repairs was .73 cent per engine-mile higher in 1907 than in 1903. This is an increase of 8.4 per cent. Considering simply the cost of repairs, this represents a considerable increase in expense, which might appear as retrogressive, but an investigation of conditions gives an entirely different aspect to this result.

Repair Cost Comparison.

In the five-year period ending 1907, locomotives on the Santa Fe have increased in number from 1,309 to 1,791, a total of 482, or 37 per cent. Among the principal types of locomotives, included in this number, there may be mentioned:

	85	Santa Fe type	117 tons on drivers.
	56	Prairie type	87 " " "
	67	Pacific type	75 " " "
	102	Atlantic type	50 " " "
Total,	310	Average,	82 tons on drivers.

In 1903 the average weight of locomotives on drivers was 46 tons. Considering only the heavy power noted above it will be observed that 310 locomotives having an average weight of 82 tons on drivers were added to the equipment in five years. This number is equal to 25 per cent of the total number owned in 1903, and is made up of locomotives having a 78 per cent greater average weight on drivers than the average locomotive of 1903.

Increase in Weight of Power.

The records of repair costs of individual locomotives for the past few years show that this item is proportional to the weight of locomotives, other conditions being equal or constant. On this basis, the repairs for the 310 locomotives designated, at the prevailing cost in 1903 of 8.67 cents per engine-mile, would amount to 15.43 cents per engine-mile; or if these 310 locomotives were added to the equipment in 1903, the total number of locomotives would have been increased 25 per cent, with a total average repair cost of 10.38 cents per engine-mile. The rate in 1907 for repairing this same class of power was 9.40 cents per engine-mile, which is .98 cent or 9.1 per cent less than the cost of repairs in 1903 under the same conditions. These figures show clearly that in spite of higher labor and material charges the cost of locomotive repairs per engine-mile is steadily decreasing and is approximately 10 per cent lower than in 1903.

While locomotive repairs in cents per engine-mile are generally accepted as a basis for cost comparison on account of the accessibility of the records from which the figures can be compiled, a more accurate method is based upon a system of locomotive road-units. The road-unit adopted by the Santa Fe is defined as follows: "The weight of locomotive on drivers in pounds, multiplied by the engine mileage between consecutive shoppings costing $500 or over divided by 100,000,000." Dividing maintenance expense by the road-unit gives the cost of repairs per road-unit, which is a comparable quantity, for locomotives under all conditions of service. The accompanying diagram, Fig. 124, illustrates in a graphical manner the reduction in locomotive repair costs per road unit in the year 1906 as compared with the year 1905. It will be observed that the cost per road-unit for the entire system in 1905 was $101, which in 1906 was reduced to $76 for freight and $66 for passenger locomotives, or an average of $71. This represents a reduction in cost of repairs of $30, or 39.4 per cent per road-unit in 1906 as compared with 1905. It is to be regretted that the road-unit costs for 1907 are not available for publica-

The Locomotive Road Unit.

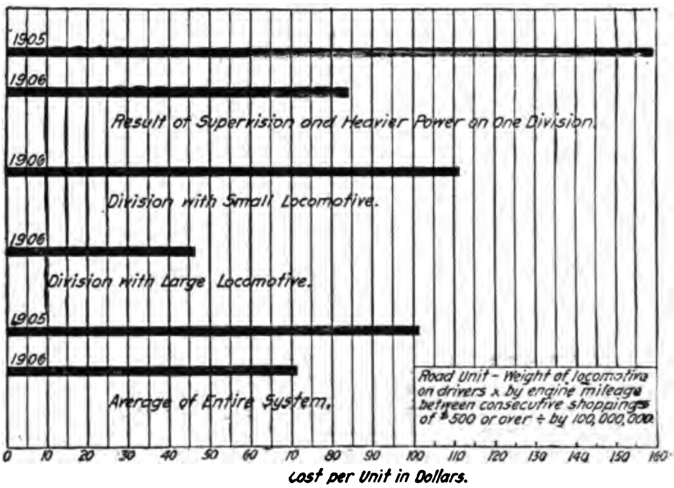


FIG. 124—DIAGRAM SHOWING REDUCTION IN LOCOMOTIVE REPAIR COSTS PER ROAD-UNIT FROM THE YEARS 1905 TO 1906.

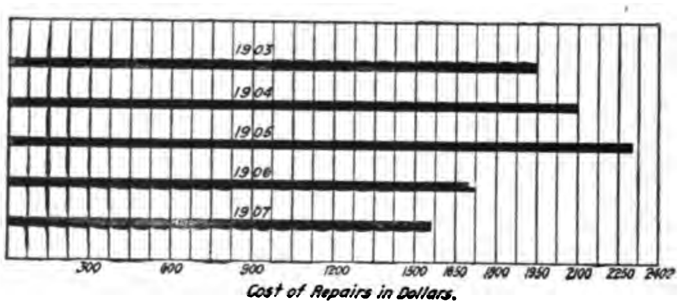


FIG. 125—DIAGRAM SHOWING THE REDUCTION IN REPAIR CHARGES PER LOCOMOTIVE FROM 1903 TO 1907.

tion at this time, as an even greater reduction is shown than for preceding years.

Among the factors entering into cost of locomotive repairs, labor is not only the largest in point of cost but also the most important. Labor is the one element that is directly under the control of the railroads. While the wage rate is more or less a product of commercial conditions it remains with railroad managements to obtain a labor output commensurate with the price paid.

Increasing Cost of Labor.

The cost of labor in all branches of industry has been steadily increasing for the past 10 years or more. The wage rate for railroad machinists, as given by Slason Thompson, has increased from $2.23 in 1897, to $2.87 in 1907, or 29 per cent. Unless an output proportional to this increased labor charge is obtained, the cost of locomotive repairs will necessarily mount upward even though other conditions remain the same. On the other hand, it is possible to obtain lower production costs even with higher priced labor by the application of scientific methods. This has been strikingly illustrated on the Santa Fe in the past five years. That the same proportional increase in wages has applied to skilled mechanics on the Santa Fe as previously indicated for other railroads is shown by the following figures: Average wage per day for the system in 1903, $3.40; 1904, $3.60; 1907, $3.88.

It will be observed that the rate in five years has increased 48 cents per day, or 14.1 per cent, and that the average wage paid skilled mechanics on the Santa Fe is $1.01 per day, or 35 per cent greater than the average wages for this class of labor as compiled by Mr. Thompson.

Labor Charges for Repairs.

With this high and constantly increasing rate, a correspondingly greater cost for locomotive repairs might naturally be expected; but the diagram in Fig. 125 shows that the reverse is true. In 1903 the labor charge per locomotive was $1,950. In 1907 this had been forced down to $1,560, a decrease of $390, or 24.3 per cent. Thus with an increase of 14.1 per cent in labor charges, the cost of this labor for locomotive repairs was reduced 24.3 per cent in the five-year period, which is equivalent to a reduction of 38.4 per cent. This is due in some measure to the individual effort system of reward, as well as to betterment methods and the large increase in the size of locomotives. The first, through the payment of bonuses for extra effort, gave the incentive for greater individual output, and the second equipped the shops with facilities whereby each man's output was limited only by his own endeavor.

Referring to the diagram in Fig. 125 it will be noted that the cost of labor for repairs in 1905 was $2,300 per locomotive, or $740 higher than in 1907. In 1904, 156 locomotives of the largest size were added to the equipment which necessarily came in for repairs the following year. Labor conditions were also very unsettled. Late in 1904 the betterment work was inaugurated along with the individual effort system, so that the principal development work took place in 1905. The workings of the new organization from that time on are shown clearly by the diagram.

Next in importance to the labor charge in locomotive repairs is the item of material. For the past 10 years there has been an upward tendency in the cost of all materials that enter into locomotive construction. With the advent of the heavy power, now common to the principal railroads, taking a greater amount of material and at a higher cost, the material item has assumed proportions that is directly manifest in the cost of locomotive repairs.

Increasing Cost of Material.

As shown by the diagram in Fig. 126, the average material cost for locomotive repairs in 1903 was $840 per locomotive. In 1907 this material charge was $1,147 per locomotive, an increase of $307, or 36.5 per cent, in the cost of material purchased by the Santa Fe for locomotive repairs. Considering the items of labor and material, it has been shown that the first, during the five-year period, increased in cost 14.1 per cent, and the second, 36.5 per cent, so that the combined cost of labor and material in 1907 represents a figure 50.6 per cent above that in 1903. In the face of this enormous increase in cost of the two principal items entering into locomotive repairs, the cost of repairs per engine-mile from 1903 to 1907 was reduced 9.1 per cent, which is substantial evidence of progress in shop methods and locomotive design.

Conditions that Influence Repair Costs.

Conditions under which locomotives are operated have a direct influence on the cost of repairs. Thus, service in districts where "bad water" prevails, results in higher maintenance charges for boilers. Also, renewals of fireboxes are much more frequent and expensive where oil is used for fuel than where coal-burning locomotives are used. Service in the mountains over heavy grades is much harder on a locomotive than on the plains, consequently repairs are higher for the same mileage. All of these factors enter into the cost of locomotive repairs and should be considered when making cost comparisons.

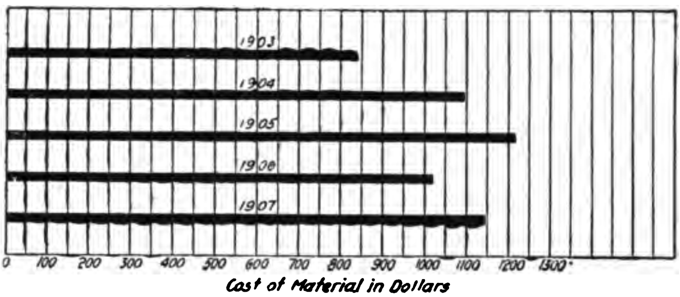


FIG. 126—DIAGRAM SHOWING INCREASE IN COST OF MATERIAL USED IN LOCOMOTIVE REPAIRS FROM 1903 TO 1907.

Locomotives are now operated on a maximum tonnage basis. The greater the capacity of a locomotive, the greater the load it must haul. In oil-burning districts, the hauling capacity of a locomotive is much greater than of the same type burning coal, owing to the greater evaporative efficiency of oil. This means that a higher firebox temperature is maintained. The effect of this high temperature is rapid deterioration of firebox sheets, necessarily involving frequent repairs and replacements with high maintenance and repair charges. The extent of this necessary firebox work on the Santa Fe largely arising from the causes as outlined is expressed by 143 new fireboxes applied to locomotives in 1907. This is one of the items contributing to a higher cost of locomotive repairs that did not exist under former conditions of tonnage rating.

Locomotive Operation and Repair Costs.

Another factor which bears directly on locomotive repairs is the manner in which locomotives are handled on the road. The wear and tear on the heavy locomotive of today hauling tonnage trains is enormous. Not only is the highest class of shop and roundhouse repairs necessary, but also the most careful and expert handling on the road, to obtain the requisite mileage from locomotives between shoppings. During the past few years, when the capacity of the railroads was taxed to the utmost, all efforts were concentrated toward moving the traffic. Economy and efficiency were necessarily sacrificed in the great struggle to handle the business. Methods were not questioned so long as the traffic moved. This injected a new spirit into the road organization which might be called "indifference." It is a product of conditions, but nevertheless, its existence is real and directly traceable in increased expenses.

The last factor to be considered as entering into the cost of locomotive repairs is that of shop methods and facilities. It goes without saying, that under the present conditions of high wages of labor and high prices of material, the best shop facilities are necessary to keep repair costs within a conservative figure. The reduction made by the Santa Fe in locomotive repairs the past few years is indicative of the progress in improved shops, facilities and organization.

The wide publicity given the "Betterment Methods" and "Individual Effort System" on the Santa Fe makes it unnecessary to discuss them at this time, but they are largely responsible for the steadily decreasing cost of locomotive repairs and renewals.

In conclusion, it may be stated that the cost of locomotive repairs is not satisfactorily expressed in cents per engine-mile. A unit should be used that takes into account the work done by the locomotive. An

absolute value is then given to the figure showing the cost of repairs. This is illustrated by Fig. 125, which shows the actual reduction in repairs to locomotives based on a road-unit that represents conditions. The present tendency toward higher locomotive repair costs is not on account of any deficiency in design of locomotives or maintenance and repair methods, but in the ordinary mile-unit used in expressing the cost of repairs.—*Railroad Age Gazette, June 19, 1908.*

THE SQUARE DEAL TO THE RAILWAY EMPLOYEE.

ANNOUNCEMENT IN ENGINEERING MAGAZINE, JUNE 1, 1907.

It is eight years since H. F. L. Orcutt, writing in these pages of a contrast in industrial policies at that time newly apparent, used the significant words: "It is economy as well as humanity to plan factories in which human life is of more account than machinery; into which human beings will not be driven by hunger, but attracted by superior hygienic surroundings—air, light, comfort—as well as by the most modern equipment for saving labor, increasing output, and raising the standard of workmanship and wages."

No one movement in the field of "Power and Production" during the intervening period is more striking than the progress of this concept in the belief and the practice of the foremost employers. We are glad that much of the current history of the advance has been written in the *Engineering Magazine.* We are especially glad now to show so brilliant an example of its extension into a branch of engineering activity which sometimes has not been closely associated with the idea of care for the individual life. Mr. Jacobs's present article is a welcome demonstration that there are railway managers by whom the "square deal to the employee" is considered equal in importance to the increase of "efficiency in the railway machine shop.—THE EDITORS.

IN the September issue of *The Engineering Magazine,* Dr. Louis Bell sounded a note of warning against the result of the American manufacturing method—devotion to securing the largest output of uniform character at minimum cost. He pointed out that this made automata out of the operatives and discouraged skilled, intelligent, and thoroughly trained artisans, to so great an extent that the quality of the men today was generally poor and unreliable.

Much of late has been written of the measures taken by manufacturing concerns to attract men of high character to their employ—to surround their men with an environment making toward integrity, sobriety, and industry, and not only to make the lot of the workman a more agreeable one, but to reward him in proportion to his efforts as well, in order to avoid the evils of "the American tendency." Although less has been written regarding their treatment of employees, some of the railroads have been doing a work along these lines unequaled in depth of motive and breadth of application.

E. P. Ripley, president of the Santa Fe system, is quoted in the Chicago *Record-Herald* of January 5, as saying:

"One of the most serious conditions which this country is facing

today is the indifference and the disregard which the employee has for the interests of the employer.

"The Santa Fe," continued Mr. Ripley, "hopes to establish a better *esprit de corps* among its employees, and expects that a liberal pension system will have this tendency. We have on this system as much loyalty as most railroads enjoy, if not more, but it is not what it should be. The lack of loyalty among employees is a condition from which all corporations are now suffering, and it presents a most serious problem."

Railroads are the pioneers of civilization and commerce in America; they pierce mountains, blaze a way through the forest, and establish a highway through the arid plains and the desert regions of the Southwest. They are antennæ or feelers, through which human society reaches out and extends its domain over untrammeled nature.

Frontier Railroad Conditions.

The hardy and adventurous, the bold and the wild, among our race, become prospectors, miners, ranchers, or settlers, or they serve the railroad which serves all. This life, hard and rough, encourages the lawless and incubates the saloon and attendant social evils. It was hardly uncommon in a frontier town to find every third house a saloon, and to their temptations the railroader, because of his extremely unsettled and nervous life, is especially subject. For instance, in one desert town there used to arrive each month on pay-day morning, from a large Pacific coast city about twelve hours distant, a number of detrimentals and gamblers who spent the next few days shearing their victims.

Work of Santa Fe in Improving Conditions of Men.

To combat the evils of the saloon and to encourage men of the superior class, with families or without, one Western road, the Santa Fe, has gone extensively into the construction and maintenance of reading rooms, recreation halls, hospitals and company cottages, and of parks and pleasure-grounds around the stations, shops, and offices.

A station called "The Needles," on the banks of the lower Colorado river, in the heart of the Arizona-California desert (the haunt of the Mojave Indian), about one hundred miles southeast of Death Valley, being a shop and division point, was typical of severe conditions. It was said that the railroader's experience was not complete until he had spent some time there; that a machinist who could hold on for three months would be promoted to master mechanic. The summer heat is intense, yet notwithstanding these severe conditions the climate is salubrious, and in winter, ideal.

The company has built at this point, without regard to expense, one of its finest recreation halls, in the mission style; a hospital is main-

FIG. 127—EXAMPLES OF SANTA FE METHODS IN MAKING AN ATTRACTIVE ENVIRONMENT FOR THEIR EMPLOYEES. THE UPPER VIEW IS OF THE SHOP YARDS AND OFFICES AT THE NEEDLES; THE GOLD-FISH BASIN HAS AN UMBRELLA COVER TO PROTECT THE FISH FROM THE GLARING SUN. THE LOWER VIEW IS OF A STATION PARK AT A DESERT POINT.

FIG. 128—A GROUP OF MOJAVE INDIANS, EMPLOYED BY THE SANTA FE AS WIPERS, SWEEPERS, AND HANDY MACHINISTS.

FIG. 129—TYPICAL READING-ROOMS, PROVIDED BY THE SANTA FE ROAD FOR EMPLOYEES. THE UPPER ONE IS IN ARIZONA, THE LOWER AT RICHMOND, CAL. THERE ARE OTHERS AT LA JUNTA, COLO., AT RATON, N. M., AND ELSEWHERE,—ABOUT TWENTY ALTOGETHER.

Fig. 130—The new recreation hall for employees erected by the Atchison, Topeka & Santa Fe Railway at the Needles, California desert.

FIG. 131—DIVISION OFFICES AT THE NEEDLES, SHOWING WIDE PORCHES AND EAVES FOR PROTECTION FROM THE DESERT HEAT.

FIG. 132—READING-ROOM FORMERLY AT THE NEEDLES, CALIFORNIA. REPLACED BY THE FINE STRUCTURE SHOWN IN FIG. 130 AND IN FOLLOWING PICTURES.

Fig. 133—Portal of the Santa Fe recreation hall at the Needles.

FIG. 134—IN THE NEEDLES RECREATION HALL. THE UPPER VIEW IS THE WEST PORTICO; THE LOWER IS THE UPPER VERANDA AND ROOF GARDEN.

FIG. 135—TWO VIEWS OF THE INNER COURT AND FOUNTAIN, THE SANTA FE RAILWAY'S RECREATION HALL FOR EMPLOYEES AT THE NEEDLES, CAL.

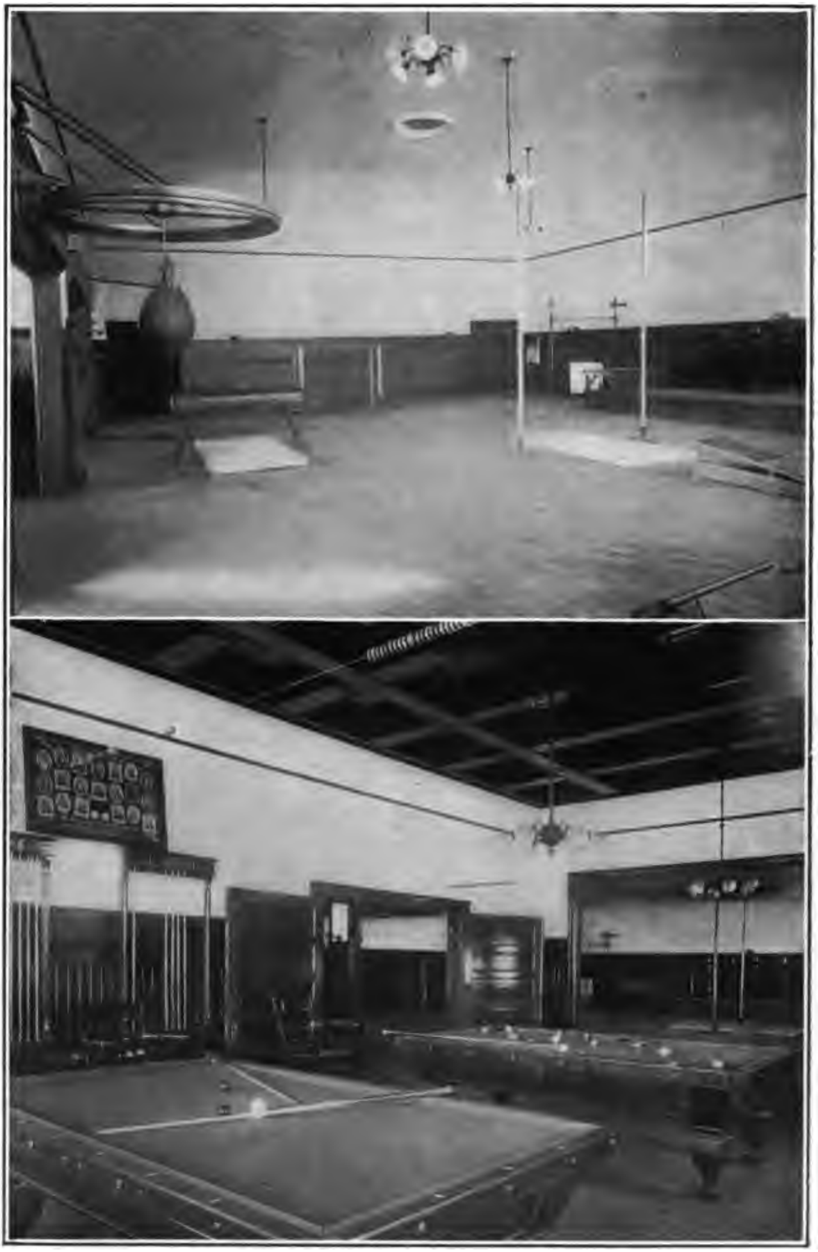


FIG. 136—GYMNASIUM AND BILLIARD-ROOM, NEEDLES RECREATION HALL.

FIG. 137—SWIMMING-POOL AT THE RAILROAD Y. M. C. A., TOPEKA.

FIG. 138—SHOP YARDS AT THE NEEDLES, SHOWING THE EFFORTS OF A PROGRESSIVE AND BROAD-MINDED MASTER MECHANIC IN MAKING THE SURROUNDINGS FOR EMPLOYEES AS ATTRACTIVE AS POSSIBLE. THE LOWER VIEW SHOWS THE BEGINNING OF THE IMPROVEMENTS, AND THE UPPER VIEW THE YARDS AS THEY ARE TODAY. FROM THE PROGRESSIVE APPLICATION OF BETTERMENT PRINCIPLES IN HIS WORK AND DEALINGS WITH MEN, THIS MAN HAS BEEN ADVANCED TO THE HIGHEST MECHANICAL OFFICE OF A GREAT RAILWAY SYSTEM.

FIG. 139—THE WRITING-ROOM AND THE READING-ROOM IN THE NEEDLES RECREATION HALL.

tained, parks have been grown, the shop grounds have been beautified, and cottages have been built. At other points where the conditions are severe, similar measures have been taken, as at Winslow, Arizona, and at La Junta, Colorado.

In all the principal cities along the railway, hospitals are maintained; each employee, from laborer to the higher officials, pays a small monthly sum (from 25 cents to $1) to the hospital association, the aggregate amounting to about $20,000 a month. Some of the trustees of the association are officials of the company, while others are employees. These trustees devote any surplus receipts over expenditures to permanent improvements, new buildings, and additional facilities. Although in this respect self-supporting, this association has received much substantial aid from the railroad in the way of donations to building funds, company buildings rent-free, and other services. All officers and employees of the association, including surgeons, receive transportation free while in the company's service, the same rule applying to injured and sick employees.

Employees' Hospital Association.

The most notable hospital is at Topeka, where the chief surgeon has his staff of five surgeons, about thirty nurses, and many other employees. At this point from fifty to one hundred patients are in the various wards all the time, not only for injuries received, but also for sickness. Many serious operations are of course performed. There are many private rooms for severe or special cases. The other hospitals render service similar to that at Topeka, there being about a dozen at various points on the road. Besides these hospitals, which aim to take care of all the cases in their own territory, there are several hundred physicians and surgeons who devote all or part of their time to the company's service at various towns of any size on the road.

Hospitals and Hospital Service.

In the principal cities ambulance service is provided; in the grounds of the larger shops there are emergency rooms, and in each shop department are men instructed in the "first aid to the injured," regular classes being held at the company's hospital.

Ambulance Service.

Other railroads carry on the same kind of good work, and the time will not be far distant when it is generally recognized that the railroad management, their employees, and the public, have common interests stronger than any differences.

These examples of the interest of the railroad for its employees are

not along the line of paternalism, but are in the nature of an investment in the character, health and good-will of the employees.

Railway Pension System.

Another advantage that has been instituted is the pension system, and still another of no small importance is the advantage of the employees to get free transpor tation for themselves and family from time to time.

The pension system is one of the latest institutions established by the company, and while modeled on preëxisting examples, it has been introduced in the belief that its terms are more liberal than those of any pension plan previously enforced. It is carried out wholly at the expense of the company, but under the conviction that the employees will show appreciation of it by increased zeal and loyalty. Nearly every employee has it in his power to benefit his employing company by the character of his work, and his influence, or to injure it by carelessness or indifference. The establishment of the pension is based upon confidence that those whose future is thus made safer will in return render the best service of which they are capable.

The general management of the pension system is in the hands of a board of five officers or employees designated by the president of the railway, and acting under his general direction and during his pleasure. This board adopts its own rules, subject to revision by the board of direction or by the president of the railway company.

Rules of Qualification for Pension.

Pensions may be granted to any retired officer or employee who has served the company continuously for fifteen years or more preceding the date of his retirement, and who, at the time of retiring, has reached the age of 65 years, or who for any cause incident to his employment has been permanently incapacitated for the performance of his regular duty and who cannot be transferred to other work which he is still able to perform. Under this provision the construction is liberal, for in the case of employees of roads leased or purchased, the period of service of the employee is construed to date from the time when he entered the employment of the road acquired, and not merely from the time when that road may have passed into the control of the main system.

Further, pensions may not be withheld nor revoked simply because the recipient may have other means of support or may be engaged in other business, if that business is not prejudicial to the interests of the corporation or its auxiliary companies; but the pension board may deny, revoke, or withhold, a pension allowance to any employee if he

FIG. 140—THE SWIMMING-POOL AND THE BOWLING-ALLEYS, NEEDLES RECREATION HALL.

FIG. 141—TEMPORARY HOSPITAL AT A DESERT POINT. THE DOUBLE ROOF IS DESIGNED TO ALLOW FREE CIRCULATION OF AIR.

FIG. 142—MAIN BUILDING, ATCHISON, TOPEKA & SANTA FE RAILWAY HOSPITAL ASSOCIATION, TOPEKA, KANSAS.

FIG. 143—ISOLATED WARD IN THE SANTA FE HOSPITAL, TOPEKA.

FIG. 144—WARD AND OPERATING-ROOM, SANTA FE HOSPITAL, TOPEKA.

FIG. 145—NURSES' PARLOR AND REST-ROOM FOR CONVALESCENTS, SANTA FE HOSPITAL, TOPEKA, KANSAS.

The Atchison, Topeka & Santa Fe Railway Company.

PENSION DEPARTMENT

PERSONAL RECORD OF SERVICE

*(Date)*________________________*190*___

TO THE BOARD OF PENSIONS,

Atchison, Topeka & Santa Fe Railway Company,

RAILWAY EXCHANGE, CHICAGO, ILL.

I personally make this record of my service with The Atchison, Topeka & Santa Fe Railway Company, and tender it as a basis for being placed on the pension rolls of that Company:

*Name in full*____________________ *Address*____________________

Employed at present in the ______________________________ *Department*

*at*____________________ *as* ____________________

*Present rate of pay $*__________*per*____________________

*Date and place of birth*______________________________

*Present age*__________*years*__________*months.*

Different employments in the service of the Company and duration of each, with salary attached to each position. (Every change in the place of employment, occupation, immediate superior officer or rate of pay to be shown as a separate form.)

[illegible]	DATES OF EMPLOYMENT.		WHERE EMPLOYED.	BY WHOM EMPLOYED	OCCUPATION	DEPARTMENT	RATES OF PAY	
	FROM	TO					AMOUNT	PER
1st								
2d								
3d								
4th								
5th								
6th								
7th								
8th								
9th								
10th								
11th								
12th								
13th								
14th								
15th								
16th								
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18th								
19th								
20th								

FIG. 146—FORM FOR PENSION APPLICATION AND RECORD OF SERVICE.

FIG. 147—THE RAILROAD Y. M. C. A. BUILDING, TOPEKA, KANSAS.

The Atchison, Topeka & Santa Fe Railway Company.

PENSION DEPARTMENT

TO THE BOARD OF PENSIONS:

______________________________who has been______years continuously in the service of the A. T. & S. F. Ry. Co. and is now employed as__________________________ at__________________________on the_____________________________________, reached the age of 65 years and under the provisions of the Pension System may be retired from service. The following statements respecting h_____ are submitted for the information of the Board of Pensions:

(HERE SHOULD FOLLOW A STATEMENT OF THE EMPLOYE'S MENTAL AND PHYSICAL CONDITION AND AN EXPLICIT RECOMMENDATION FOR RETIREMENT OR FOR CONTINUANCE IN THE SERVICE.)

(IF RECOMMENDED FOR RETIREMENT GIVE CAREFULLY CONSIDERED STATEMENT OF CHARACTER OF SERVICE RENDERED)

Does employe desire to be retired? ______________________________

Date when last on duty if now disabled______________________________

Date to which wages were paid if now disabled______________________________

Signature______________________________ Official Title____________________

Date______________________________ Location__________________________

Respectfully forwarded to______________________________(Date)________________
who is my immediate superior officer.

FIG. 148—FORM FOR RECOMMENDATION OF AN EMPLOYEE'S PENSION APPLICATION.

FIG. 140—A WIRE-SCREENED BUNGALOW IN THE SHOP YARD FOR A "BACHELOR" MASTER MECHANIC, WHO LIVED WITH HIS WORK. SANTA FE RAILWAY.

FIG. 150—READING-ROOM IN THE RAILROAD Y. M. C. A., TOPEKA, KANSAS.

FIG. 151—SANITARY WASH- AND LOCKER-ROOM, SANTA FE SHOPS, TOPEKA.

prove himself wholly undeserving through immorality or other misconduct.

Pensions are not allowable, further, if the officer or employee has made or enforced any claim for damages against the company for injury or accident occurring within three years of the time when the applicant is retired or leaves the service. Neither are they allowable if, during the fifteen-year period, an applicant has been engaged in business or employment other than the service of the company. The fifteen years must be continuous, and voluntary withdrawal for two months or more is sufficient to constitute a break; but leave of absence duly granted, or even suspension or dismissal if followed by reinstatement within one year, are not regarded as interrupting the continuity of service.

The amount of the pension is contingent upon three elements: (1) The highest average monthly pay received by the pensioner during any consecutive ten years of service; (2) the number of years he has been in the employment of the company or its auxiliary companies; (3) the character of the service he has performed. The general rule is that employees whose highest average monthly wage during any consecutive ten years was $50 or less may receive 1½ per cent of this monthly average for each year of service, while employees whose pay exceeded $50 per month may be granted for each year of service 1½ per cent on the first $50 and three-fourths of 1 per cent on the remainder. A minimum of $20 a month and a maximum of $75 per month are, however, arbitrarily provided. If the pension computed as above falls below the lower figure it is raised to $20, and if it rises above the higher figure it is reduced to $75. In case of exceptionally long and unbroken service with a first-class record, the board of pensions, with the approval of the president, may increase by as much as 25 per cent any pension as calculated under the preceding rule, provided always that the total sum paid does not exceed $75 a month.

Amounts Granted for Pensions.

Application for pension is made by filling out a blank, of which reproduction is given on page 257. The signature of the employing officer must be secured in approval, and the application is then passed to the board of pensions through its secretary. In addition to the information called for in the application form, the board may ask for any further particulars it thinks necessary, and may require a physical examination by the company's surgeon, where the retirement is asked on the ground of incapacity. The acknowledgment of the receipt of the application

and notice of the action taken upon it is communicated to the applicant through his employing officer.

The resolution of the board of directors adopting the pension system sets forth that it has been instituted "in order to enable the employees of the company who have rendered long and efficient service to retire when advanced age makes relief from work desirable." This sense of security in old age or in disability incurred in service has proved elsewhere to be one of the greatest incentives to loyalty, contentment, and faithfulness in service. It has as yet found comparatively little application in industrial management in the United States.

By the institution of the system the Santa Fe road seems to be taking a long step toward the betterment of permanent relations between employer and employed. The probability that it will be fully justified and repaid by the results does not diminish in the least the credit due to the far-sightedness and the praiseworthy effort of those who are responsible for its introduction.—H. W. JACOBS, *in Engineering Magazine, June, 1907.*

INDEX.

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